
ACADEMIÆ HARVARDIANÆ SIGILLUM
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LECTURES

TO FARMERS

ON

AGRICULTURAL CHEMISTRY.

(Georg Paul)
BY ALEXANDER PETZHOLDT.

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LECTURES TO FARMERS ON AGRICULTURAL CHEMISTRY.

BY ALEXANDER PETZHOLDT....London, 1844.

INTRODUCTORY REMARKS BY THE AMERICAN EDITOR.

In conformity with the design of the Farmer's Library, we have selected for republication, a work recently published in England under the above title. It seems to be as exactly adapted to our purpose as if it had been written to illustrate it. The taste for Scientific Agriculture in the United States has created a demand for the very information which these lectures supply; for, much as that taste has been whetted and gratified by our numerous and well conducted Agricultural journals, it was not yet quite prepared to digest such (more technical and profound) works as Davy's and Liebig's. These, however justly celebrated for their efficacy in opening to common inquirers a clearer view of the field of Agricultural Chemistry, were yet better adapted to the more advanced state of scientific knowledge in Europe. Even there these works had been deemed rather too classical to be easily comprehended by the generality of readers; and hence it is, that in a commendatory notice of the Lectures here presented to American Farmers, it is observed in a late number of the Edinburgh Quarterly Journal, (than which no better authority need be desired,) that, among those writers who have endeavored to present the subject in a *plain and easy* form, is the author of these Lectures to Farmers. "He goes over the usual series of subjects, and treats of them in a clear and intelligible manner—occasionally describing experiments, by which the phenomena of Chemistry may be exemplified. *Any one*, by a careful perusal of this work, will be in a condition to enter with profit on the study of those of a more profound and elaborate character. The author seems to have formed a just conception of the benefit that may be expected to be conferred by Chemistry on Practical Agriculture."

The author himself avows to his pupils, as will be seen, that in undertaking his task he was animated chiefly by a wish to increase their interest in the subject, and to excite in them a desire, *with the aid of Professor Liebig's classical work*, to study this important science more profoundly. "My aim (he adds) is to impart to you the *necessary preliminary qualifications* to *prepare you* for entering upon that deeper study, and to facilitate your progress in it. The motive which has induced me to prepare such a course of lectures is the complaint I have heard from many of you, that, being unacquainted with the elements of Chemistry, you have found it difficult to understand the questions which are *at the present moment so warmly discussed*, respecting the theory and practice of Agriculture; or to follow the arguments employed in the attempts made to establish the principles of Agricultural Chemistry." If instruction thus prepared could be deemed useful and necessary to promote practical Agriculture, in a country where that and other arts and sciences have made much greater progress than in this—great as that progress has been of late years—how much more pregnant of public benefit must be the wide diffusion of it in this country, where almost every one has a fee-simple in the soil he tills, and reaps a personal advantage from its

slightest melioration; and at a time, too, that a general and most auspicious change in public sentiment is lifting Agriculture to its high and proper rank among industrial pursuits—rendering it not only more surely profitable, but by comparison quite as dignified, attractive, and intellectually amusing, as the so-called learned Professions?

If we do not stop to adduce formal argument in support of the natural and necessary connection between the Natural Sciences, including Chemistry, and the Art of Agriculture; and to explain how acquaintance with the former cannot fail to ensure greater success as well as more honor to the latter; it is because we are persuaded, as before intimated, that the public mind has already been duly impressed with the truth of the proposition; and if called upon to justify this impression, we should ask no better support than we find in the last (third) number of Mr. Colman's "European Agriculture and Rural Economy"—the highly honorable as well as instructive result, we should say of philosophical, as well as of "personal observation." Alluding to, and giving instances of immense increase of acreable crops within the last few years, he exultingly exclaims, in favor of the *influence of Knowledge upon Agriculture*—"Who can doubt that these extraordinary results are the consequence of that intelligence and enlightened skill which are equally the instruments of success in every other art? But it seems idle to argue this point. All the improvements which have been made in Agriculture are as much the result of the application of Mind and of Knowledge to the subject, as any of the improvements made in Manufactures or the Mechanic Arts. Accident has produced nothing. The dull plodding laborer originates nothing, any more than the beast which he drives. The present advanced state of Agriculture, as a practical art—all the improvements which have been effected in it—are due to the highly intelligent minds—the men of science, of learning, of observation, of skill—who have applied their attention, and have devoted their time, talents and fortunes to it."

Concurring heartily in these impressions, we will only express further the hope that every Farmer will soon feel and act upon the obligation to provide for himself and his family a suitable LIBRARY, to the end that amusement and instruction may accompany and give zest to all their domestic and out-door duties and occupations. To that ever-convenient source let them turn, in hours of leisure, for the light which written experience may surely shed on the culture of the Garden and the management of the Dairy—on the art of Planting and Pruning—on the composition of Soils and Manures—in a word, on the whole round of industrial and economical pursuits. As, in the heat of the midsummer's day, the Laborer repairs with eagerness to slake his thirst in the limpid stream, so let the Farmer and his family, in the long winter's night, turn to his Library, as to a perennial fountain, for draughts of elegant and enduring knowledge. Here, in his books, may the rich Planter find a charm against the curse of *ennui*, that ever waits on unlettered opulence; and here, too, may he who has been overtaken by adversity—the Merchant or the Mechanic wrecked in the vicissitudes of trade—find an excellent panoply against the "slings and arrows of outrageous fortune."

JOHN S. SKINNER,

Editor of the Farmer's Library.

AUTHOR'S PREFACE.

THE last thirty years,—the time which has elapsed since the establishment of peace in Europe,—has been an era remarkable for the rapid progress of the practical arts; but no attentive observer can fail to have perceived that their advancement has not been by any means equal and consentaneous. Whilst some have reached a point of perfection scarcely admitting of improvement, others have felt but slightly the forward impulse. The difference has arisen solely from one cause, namely, the greater or less extent to which the discoveries of science have been made to apply to practice.

As it is with art generally, so also the success of individuals has been most chiefly promoted by the possession of a scientific basis upon which to rest their practical experience.

These important truths are perhaps less recognised by agriculturists than by any other class of practical men. To do as their fathers have done, especially when they can refer to predecessors successful in the pursuit of fortune, is deemed to be an unquestionable proof of wisdom. But this is a great error. As time advances, circumstances change, and as every other interest around him improves, the FARMER must arouse himself to find better means of cultivating his land, and surer methods of obtaining good crops, than were known to his forefathers. He will have the foreign corn-grower to contend with, and where can he look for assistance except to the discoveries of science? What better method of traveling could at one time have been dreamed of than the mail coach? yet science has established railways. What success more brilliant could be expected than was achieved by the British navy during the last war?* Yet it has been decided that a knowledge of abstract science is indispensable to the future protection of the country. In like manner the next generation of farmers, if the soil is to be cultivated with success, must be acquainted with the natural sciences, with Botany, Geology, and above all with Chemistry. When the scientific principles upon which the art of Agriculture depends shall be fully known, and the practice founded on it generally followed, the amount of our present crops will be as much a subject of tradition as the pace of the old stage-coach, which dawdled

* Continental War.—[ED.

away twelve hours in accomplishing a journey of seventy miles, is to the present generation.

But is it wise, it may be asked, to postpone the benefits of science to the next generation? Would it not be well to seize at once on every assistance offered for the advancement of this supremely important art? Doubtless it would, and if but few persons, after they have arrived at manhood, can become qualified to be discoverers in science, no man need refuse to benefit by the discoveries of others. In order to do this, a certain amount of information on scientific subjects is indispensable. The farmer must know something of the composition of the various plants he cultivates, and of the manures which he carries on his land, before he can derive any advantage from the statements made of the benefit of this or that substance to various crops. A very little such knowledge, provided it be really scientific, will enable him to escape being misled by interested persons, or from purchasing materials as manures which are either useless in themselves, or are sold at ten times their real value.

A perusal of this little work with ordinary attention will furnish the necessary amount of chemical information for the purposes of the farmer. He will learn enough from it to satisfy him that science is not to be despised, and if it open his mind to the reception of the important truths made known by the great chemists of the present age, and enable him to derive, from the writings of Liebig especially, all that has been of late discovered relating to Agriculture, the design of the writer will be accomplished, and the profit of the reader secured.

The reader will find generally all technical terms explained as they occur; a few left undefined in the text will be found in the Appendix.

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LECTURES TO FARMERS

ON

AGRICULTURAL CHEMISTRY,

BY ALEXANDER PETZHOLDT.

LECTURE I.

Introduction....General View of the Subject of these Lectures.

GENTLEMEN:—It is my intention, with your permission, to place before you, in a series of Popular Lectures, a brief sketch of Agricultural Chemistry.

In undertaking this task, I am animated chiefly by a wish to increase your interest in the subject, and to excite in you a desire to study this important science, with the aid of Professor Liebig's classical work, more profoundly. My aim is to impart to you the necessary preliminary qualifications,—to prepare you for entering upon that deeper study, and to facilitate your progress in it.

The motive which has induced me to prepare such a course of lectures, is the complaint I have heard from many of you, that being unacquainted with the elements of chemistry, you have found it difficult to understand the questions, which are at the present moment so warmly discussed, respecting the theory and practice of agriculture; or to follow the arguments employed, in the attempts made to establish the principles of agricultural chemistry.

To enable me to attain my purpose as completely as possible, you must permit me to introduce, at the beginning, many things that will appear to some of you superfluous; and even to others, perhaps, utterly useless. I trust that I shall, however, during my course, succeed in convincing you of the fallacy of such notions, if your patience and attention answer my reasonable expectations. It is especially in this last respect that I think it due to my subject, to you, and to myself, to offer, in a few introductory remarks, a condensed outline of what you may expect to hear, and to learn, in the course of these lectures. In this manner you will gain, at once, a certain insight into the connexion of the particular subjects which I shall discuss, and will thus the more readily grant me your undivided attention in matters which apparently have but a remote bearing on the subject before us.

The life of plants, as well as of animals, depends upon certain conditions. In these lectures, as we have to consider only those conditions which belong to the science of Chemistry, we shall designate air and water as *essential* conditions to the life of plants; the soil as a *non-essential* condition. Certainly none of you will dispute that air and water are essential conditions of vegetable life; but it may excite your astonishment that I should call the soil a non-essential condition. I beg you, however, to remember, that a great many bulbous plants, the majority of the aqueous plants, and nearly all marine plants, exist and thrive without soil, requiring for their growth and subsistence, nothing but air and water, together with the several constituents of these substances; and yet all these are living plants, subsisting

upon the same food as those plants which require soil for their existence. For this fact you may unhesitatingly trust to chemical experience. You will, therefore, easily understand, that taking a general view of the question, and considering it in a more extensive sense, the soil is not an absolutely essential condition of vegetable life; although the growth of certain plants, and especially of all those the cultivation of which is your main object and pursuit, depends upon the presence of soil. I have intentionally, and even at the risk of being misunderstood, given to this point precedence of all the other subjects of consideration, in order that I might immediately, and at the very outset of my lectures, draw your attention more especially to the importance of air and water in the nourishment and growth of plants.

Thus, since air and water are essential conditions, whilst the soil is only a contingent condition of vegetable life, the first part of my lectures will be devoted to a special investigation of the chemical properties of these two substances.

With regard to the atmospheric air, you must in the first place obtain a knowledge of its constituents; viz. oxygen, nitrogen, carbonic acid, water, and ammonia; and then, I trust, the solution of the question, what is the *origin* of these various constituents? will not be uninteresting to you. We shall not neglect to notice that remarkable tendency of aëriform (gaseous) substances, completely and uniformly to intermix, notwithstanding their different gravity, technically called *the diffusion of gases*. We shall proceed in the same manner with water; and we shall have to bestow particular attention upon the *accidental* constituents of water, that is, such as it possesses in its various states, as rain, snow, spring water, river water, or sea water; since, as we shall hereafter find, these constituents supply very important and indeed indispensable nourishment to considerable families of vegetables. We shall then conclude this first part of our course, with a minute consideration of the nature and constitution of the soil, beginning with its sources, namely, the wearing down or degradation of rocks and mountains; and that will also be the proper time for discussing the origin, and ascertaining the properties, of one of the constituents of the soil of arable fields, namely, *humus*.

In the second part of these lectures my intention is to discuss the chemical constituents of plants; and for this purpose I shall divide them into general and particular constituents; and shall endeavor to solve, as satisfactorily as possible, the question whence plants derive the one, and whence the other class of these constituents. If you choose to apply the term *theoretical* to the first part of these lectures, you may appropriately designate this second part of the course *controversial*, since I shall here have to contend against a great number of erroneous opinions which prevail respecting the nutrition of plants.

Finally, in the third and last section of the course, which (if we have agreed upon the notions and opinions involved in the second part) will contain nothing but plain matters of fact, we shall occupy ourselves with the practical part of agriculture; with the nature and uses of fallow; with the rotation of crops; and manuring.

The whole is to be concluded by a general summary and review of the subjects discussed, with practical remarks, to enable you to carry out in practical operations the facts and principles you will have been taught.

LECTURE II.

ON ATMOSPHERIC AIR.

Essential constituents of Atmospheric Air....Oxygen, Nitrogen, and Carbonic Acid.... Water....Ammonia.

You know, Gentlemen, that the air surrounding our earth is termed the *Atmosphere.* In our present more especial consideration of the atmosphere, we may altogether lay aside all considerations of its *physical,* and occupy ourselves exclusively with the investigation of its *chemical,* properties. The atmosphere being a mixture of substances, which, considered individually, differ widely from each other in their properties, its examination as a whole would not afford us an adequate notion of its nature, it would not assist us in our present purpose; we are, therefore, compelled to examine its constituents severally.

Two of those constituents, namely, *Oxygen* and *Nitrogen,* are present in the air in such preponderating proportions, that for a long time they were thought to be the only essential constituents of the atmosphere; and it is this preponderating proportion which induces me to treat of them first.

Oxygen is a gaseous substance, somewhat heavier than atmospheric air, and is characterised by its property of sustaining combustion, bodies burning in it with extraordinary vividness: of this you may easily convince yourself by placing an ignited splinter into a bell-glass filled with oxygen; the splinter, which burned only with a dull flame before, will immediately begin to burn rapidly and with great brilliancy. This substance has been called oxygen, (from two Greek words signifying, *sourness*—and, *to generate*) because the combinations which it forms with a great many substances, are of an acid character; it is, likewise, not uncommonly termed *vital air,* because it alone is capable of sustaining the respiration, and consequently the life of man and of animals. This latter term might properly be considered the most correct under all circumstances, since the chemical experiments of modern times have proved that there exist other substances besides oxygen producing acids in their chemical combinations with other bodies, and which, therefore, have an equally good title to the name of *Oxygen.*

The capability of atmospheric air, therefore, to sustain respiration and combustion, is solely owing to the oxygen it contains; and which forms about one-fifth of its mass. If you deprive atmospheric air of this constituent, it will no longer sustain combustion or respiration; a lighted candle placed in air deprived of its oxygen will be instantly extinguished; and an animal under the same circumstances will die. Permit me to illustrate this fact by an experiment.

Under a bell-glass filled with atmospheric air, (and which you see stands in a particular apparatus, called a pneumatic trough),* I have placed a piece of phosphorus supported on a float, and I ignite this phosphorus by means of a red-hot wire introduced through the aperture at the top of the bell, which is provided with a glass stopper, and immediately close it again. Now, the combustion of this substance deprives the air, confined by the water, of its oxygen; the phosphorus at last is extinguished from want of oxygen. At the same time you perceive, very distinctly, how the confining water ascends during the cooling of the bell-glass, which had been heated by the combustion of the phosphorus; and a simple measurement of the amount of air remaining will show that the fifth part of it has disappeared. This part consisted of oxygen, which has chemically combined with the phosphorus, and dissolved in the water. If you now introduce a burning splinter into the glass jar, it will be immediately and completely extinguished. Analytical Chemistry would, however, be very defective if we were not able to obtain a more exact knowledge of the amount of oxygen contained in atmospheric air, or in other gaseous mixtures, or of its total absence therefrom, than can be done by means of the combustion of phosphorus, or by the extinction of a burning wood splinter.

In order, therefore, to give you some idea of the means by which chemists are able to ascertain with far greater exactness the amount of oxygen contained in the

* See Appendix.

air, I have placed here before you an apparatus which is not inappropriately termed an Eudiometer, because by its means we are enabled to detect and to determine the precise quantity of oxygen in the air, *i. e.* that constituent of the atmosphere which imparts to it its property of sustaining respiration. Now, by adding to the amount of air contained in this carefully graduated glass tube (the amount in the tube before us is 300 volumes) a measured amount (239 volumes) of hydrogen (a gaseous substance which we shall consider afterwards when treating of water), I have secured all the preliminary conditions upon which depends the attainment of a correct result of our experiment. Nothing more is needed than to transmit an electric spark through this gaseous mixture, by means of a contrivance fixed, as you see, to the upper and closed part of the tube. The very moment that you see the electric spark discharged, you perceive a fiery flash to pass through the whole gaseous mixture; the mercury ascends into part of the tube, and you see further, that the inner wall of the tube is covered with a slight cloud of watery vapor. If we now examine how many volumes remain of the original mixture of atmospheric air and hydrogen, (this consisted, you will recollect, of 539 volumes; *i. e.* 300 volumes of air × 239 volumes of hydrogen = 539) we find that we have now only 350 volumes in the tube, and thus that the loss is 189 volumes. The third part of this loss consisted of the oxygen contained in the air; and which thus must have occupied sixty-three volumes previous to its disappearance. In order to ascertain how much oxygen was contained in the atmospheric air we have examined, we need only have recourse to a simple rule of three calculation; and we shall find as the result, 300 : 63 : : 100 : 21, and thus, that according to our experiment, 100 volumes of atmospheric air contain exactly 21 volumes of oxygen; and this proportion is invariably the same, as the most careful investigations of numerous chemists, extending over a period of nearly fifty years, incontestibly prove. It is especially worthy of notice, that these experiments have been made upon air from the most different regions, and various elevations, and yet in no case was there any notable difference in the proportional amount of oxygen. Gay-Lussac ascended in a balloon to a height of 21,510 feet, the highest elevation, by-the-bye, ever attained by man; (Alexander von Humboldt, in his ascension of the Chimborazo, reached a height of 18,330 feet), and even the air which Gay-Lussac brought down with him from this elevation, formed no exception to this general rule.

But, you may be inclined to ask me, Gentlemen, upon what principle does the experiment which you have made, depend? what purpose does the hydrogen serve? and, finally, how do you know that the third part of the loss of the gaseous mixture was oxygen? Such questions are perfectly natural to those unacquainted with chemistry; and I shall, therefore, before proceeding any further, first endeavor briefly to satisfy you upon these points. Hydrogen is a gaseous substance, capable of chemically combining with oxygen; and this combination takes place in the exact ratio of two volumes of the former, to one volume of the latter gas; the product of this combination is water. Had I therefore had ten volumes of oxygen, and twenty volumes of hydrogen in the Eudiometer tube, confined by means of mercury, this fluid, upon the transmission of an electric spark, would have ascended into the tube, so as completely to occupy the space originally filled by the two gases; whilst the gases themselves would, with an instantaneous fiery flash, have completely disappeared, leaving nothing behind them but a slight moisture upon the inner surface of the glass tube. This moisture is the new-formed product, namely, pure water, which you, therefore, are to consider a combination of two volumes of hydrogen with one volume of oxygen. You will, in the course of these lectures, have other opportunities of convincing yourselves of this fact. If, therefore, I am desirous of ascertaining the proportional amount of oxygen contained in any gaseous mixture, I need only add to this mixture,—of course always observing certain precautions,—twice its amount of hydrogen to be certain, that upon transmitting the electric spark through the mixture, the whole amount of oxygen will combine with twice its volume of hydrogen; *i. e.* with the amount necessary for the formation of water; and that both the gases will thus disappear, merging together into this new compound. Now I hope you will understand *why* the chemist is justified in assuming the third part of the loss which the gaseous mixture has sustained, upon the transmission of the electric spark, to be oxygen. And you will now also understand why in our experiment

upon 300 volumes of atmospheric air, I employed only 239 volumes of hydrogen, —far less than double the amount of the air, which would have been 600 volumes; for since only little more than one-fifth of these 300 volumes consisted of oxygen, viz: sixty-three volumes, even 126 volumes of hydrogen would have sufficed for the formation of water (126 : 63 :: 2 : 1). Consequently of the remaining 350 volumes, 113 volumes consist of the hydrogen added in excess, and only 237 volumes,—or giving the numbers in *per cents*, seventy-nine out of every hundred volumes consist of the other constituents of the atmospheric air which we have mentioned above, and these principally of nitrogen.

And now we will enter upon a more minute consideration of NITROGEN.

This element is, like oxygen, a gaseous substance, not characterized by any particularly striking properties when in its isolated state; that is, uncombined with other substances. It is in this state that it is contained in the atmosphere, being therein only mechanically intermixed with oxygen. The term *azote* has been applied to this substance from its inability to support respiration. An animal placed in nitrogen gas dies from want of oxygen, just as a burning candle is extinguished when immersed in it, as you have already had an opportunity to observe. The principal design of the existence of nitrogen in the atmosphere (of which, as we have just now observed, when treating of oxygen, it constitutes seventy-nine parts in every 100), appears to be nothing more than to dilute the oxygen intended for the respiration of man and animals. Medical observations prove that the continuation of health, and of life, necessarily depends upon this dilution. For our present purpose, Gentlemen, it is quite sufficient for you to know that nitrogen exists in the air; that it forms the greatest proportion of the whole mass of the atmosphere; and that it possesses a certain importance only from its negative properties.

The case is altogether different with respect to the remaining constituents of the atmospheric air, which although compared with oxygen and nitrogen, they exist in it in an infinitely smaller proportion, yet they are of the highest importance, as will hereafter be manifest to you; and especially, Gentlemen, when you shall have learnt their influence on vegetable life. These constituents are, CARBONIC ACID, WATER, and AMMONIA, and you must consider these, notwithstanding the minute proportion in which they are present, as *essential* constituents; since they are at all times and in all places found in the atmosphere. We will begin with the consideration of carbonic acid.

CARBONIC ACID is a gaseous substance, like oxygen and nitrogen, having a specific gravity far heavier than that of atmospheric air. It is incapable of supporting respiration, and extinguishes flame as readily as water. It possesses the properties of an acid. Carbonic acid is not a simple substance, but a chemical compound of charcoal (termed carbon by chemists) and oxygen, whence its name of carbonic acid. I have here several glasses filled with carbonic acid, and intend now to exhibit to you the properties of this substance by a few experiments.

You perceive that a lighted candle placed in one of these glass vessels is immediately extinguished; this will leave no doubt in your mind of the inability of carbonic acid to support flame, whilst the experiment which I shall make presently, will give you some notion of the far greater specific gravity of carbonic acid than that of atmospheric air. You see I have here three common tumblers, having each a burning wax candle fixed within them at the bottom. If I pour water into the first of these tumblers, it will not surprise you to see the flame extinguished, as soon as the water, displacing the atmospheric air contained in the tumbler, has mounted high enough to reach the flame; indeed, you find this occurrence so natural, that you might reasonably wonder at my making this apparently superfluous experiment. I beg you, however, Gentlemen, to bear in mind, that the displacement of the air from the lower part of the tumbler is owing to the greater gravity of the water, and that the immediate cause of the extinction of the flame is the circumstance that, together with the atmospheric air, its amount of oxygen has been displaced. Indeed, you know, from what I have stated before, that water also contains oxygen; but this oxygen has already served for the combustion of hydrogen; this combustion being the very process of the formation of water; and the same oxygen, therefore, cannot again serve for the combustion of the elements of the wax.

Now, upon pouring carbonic acid into the second tumbler, just as I did with water

into the first, you see the light equally extinguished, although, of course, you cannot see the carbonic acid poured into the tumbler, since this is a gaseous and perfectly transparent substance. Owing to its specific gravity being greater, it displaces the atmospheric air, as the water did in the first experiment, and being incapable of supporting flame, the candle is extinguished. The same cause which prevents water from supporting combustion, renders carbonic acid incapable of supporting it, notwithstanding its amount of oxygen. Just as the oxygen in the water has been used for the combustion of the hydrogen, so in the carbonic acid it has served for the combustion of the carbon; and, to require that the oxygen, after its chemical combination with the carbon, should still be capable of combining chemically with the elements of the wax, that is, should contribute to the burning of the wax-light, would be absurd, implying that matter already burnt would be capable of burning a second time.

Finally, you observe that the light in the third tumbler has continued to burn with a steady flame, and this may serve as a proof that the extinction of the flame in the second tumbler was owing to no other cause than the pouring of carbonic acid into that tumbler.

I would now call your attention to a fourth tumbler which I have filled with carbonic acid gas to the very brim; you may convince yourselves that it is so filled with carbonic acid, by the fact that a light is extinguished even when placed in the uppermost layer of the air contained in this tumbler; I will place this aside for some time, as I shall afterwards have occasion to recur to it.

You will recollect that I have called this gas *an acid*, and before we pass on to the consideration of other subjects I will show that this gaseous body really bears the character of an acid. I deem it absolutely necessary that you should distinctly apprehend what chemists mean by the term "*acid*," since without this knowledge the remarks which I have to make might prove unintelligible to you.

There exist two great classes of compound substances, (whether solid, liquid, or aëriform, *i. e.* gaseous, it matters not,) which cannot be brought into contact with each other without giving rise to a mutual strife or contest, ending in the more or less complete annihilation of their respective properties; the final result of this is the formation of a new and more complex compound, in which, under favorable circumstances, we no longer perceive the characteristic properties of either one or the other substance. The one class of those substances is called *acids*, because such of them as are soluble in water have a sour or acid taste; the other class, which have also, when soluble in water, a peculiar taste called *alkaline*, we designate by the name of Salt-bases, or simply "*bases*," because they form with acids those chemical combinations commonly known as salts. To furnish you with a familiar illustration of this, you all know that sulphuric acid (or oil of vitriol,) which is soluble in water, has a sour taste. Should you deem it unadvisable to use your own organs of taste in order to convince yourselves of the fact, you may employ for this purpose slips of paper, which have been rendered of a blue color by the coloring matter of the purple Dahlia, or of Litmus, being steeped in a strong infusion of these substances, and known as Georgina, and Litmus papers; since all substances which cause a sour taste in the mouth, have also the property of converting the *blue* color of these papers into RED. Further, you are all acquainted with quick lime; this is a base, or *basic* substance soluble to a certain extent in water, possessing an alkaline taste, and the property of changing the blue color of these papers into GREEN. Now, if I bring these two substances, sulphuric acid and lime—an acid and a base—into contact with each other, they combine, forming a salt which leaves the blue color of the paper unaltered, and has neither an acid nor an alkaline taste: you all know this body under the name of Gypsum. It may be as well just to mention here, that salts are usually denominated in scientific language by terms referring to their constituents; thus, in the case before us, we designate gypsum, *Sulphate of Lime*; or when we speak of groups of salts, we call them Sulphates, Nitrates, Carbonates, &c. according to the acids entering into their composition; the salts implied by these terms may, of course, have very different bases. On the other hand, salts are designated by terms referring to their bases without any regard to their constituent acid; thus we speak of lime-salts, iron-salts, copper-salts, &c.

After these preliminary explanations, I will now proceed to prove to you, that carbonic acid possesses the characteristic properties of an acid; I introduce into

this tumbler filled with carbonic acid a slip of moistened paper, tinged blue with the coloring matter of the dahlia; you see the paper assumes a reddish tint; this tint, however, is but feeble, because carbonic acid is a weak acid; (this character of being a *weak* acid is also manifested by its being easily expelled from its combinations by nearly all other acids;) you will perceive also that the red tint thus imparted to the paper soon vanishes; this is owing to the carbonic acid being a volatile substance, and evaporating together with the water, during the drying of the paper.

Having thus demonstrated to you the principal properties of carbonic acid, I have now still to consider the question, in what proportion this substance is present in atmospheric air, and in what manner we presume it may be detected and investigated.

According to the best accredited experiments of very many chemists and natural philosophers, carbonic acid has invariably been found to be one of the constituents of atmospheric air, as I have already stated, but its proportional amount is exceedingly minute. It has been ascertained that only four volumes of carbonic acid gas are present in every 10,000 volumes of atmospheric air. It is, however, proper to remark that this amount is about the average of the results obtained in a great many experiments made upon atmospheric air taken as far as possible from any known sources of carbonic acid.

Here I shall again take occasion to afford you a proof of the degree of certainty and accuracy with which chemists are capable of detecting and ascertaining the exact amount of the most minute quantities of one substance, though intermixed with a proportionally extremely large amount of another. In the course of these lectures I shall not let slip any opportunity of impressing upon your minds how confidently you may rely upon conclusions rightly deduced from chemical experiments, well knowing with how much distrust the assertions of chemists are still received in certain quarters, owing to the circumstance that people are altogether ignorant of the means and resources of chemistry. The apparatus which you see here before you will, I hope, demonstrate to you that the detection of the carbonic acid contained in any gaseous mixture is accomplished with certainty, and its amount may be determined with the utmost accuracy: to render this perfectly intelligible to you, I must make a few preliminary remarks.

I have already shown you that carbonic acid possesses the characteristic properties of acids, and therefore is capable of combining chemically with bases, forming a class of salts called carbonates. Experience has proved to us that several of these carbonates are insoluble in pure water; now the method of exhibiting the amount of carbonic acid present in a gaseous mixture rests upon these two facts. We need only bring a base, dissolved in water, and such an one as forms an insoluble salt with carbonic acid, (an aqueous solution of quick lime, *lime water*, for instance,) into contact with the gaseous mixture under investigation (which is best and most rapidly done by agitation,) and if any carbonic acid be present, the solution will become troubled, and assume a whitish milky appearance, owing to the formation of carbonate of lime, which substance is insoluble in pure water. If the gaseous mixture under investigation contains no carbonic acid, the lime-water will remain clear and pellucid. I have here a perfectly clear aqueous solution of lime; I pour it into this tumbler, and you see that a pellicle immediately forms on the surface of the fluid; this consists of carbonate of lime, and its formation is owing to the atmospheric air contained in this room yielding its amount of carbonic acid to the solution of lime as soon as it comes into contact with the solution. You must consider the formation of this pellicle as a convincing proof of the presence of carbonic acid. Now, if by some means or other I had measured off a certain definite amount of air, and made my experiment upon this measured quantity, I should be able to find, by means of the balance, and, observing certain precautions, the exact amount of carbonate of lime which it would form; and from this amount to determine by calculation what space or volume the carbonic acid occupied as a constituent of the air; since we know by experience that a definite amount of carbonic acid invariably combines with a definite amount of lime; in other words, that the proportions in which carbonic acid and lime combine chemically, are definite and invariable. Chemists, however, do not employ this method in their investigations, because the results thus obtained are not sufficiently correct, for reasons which we need not at present expatiate

upon; on the contrary they gladly renounce the facility thus afforded of ascertaining the presence of carbonic acid by the sense of sight (for the production of a carbonate insoluble in water renders it visible,) and rest satisfied with attaining this end by means of "the balance" alone; since this enables them to accomplish their purpose with a far greater degree of accuracy. This latter method, of course, renders the production of a carbonate insoluble in water quite immaterial.

After premising these remarks, the bearing of which you will immediately perceive, we return to the consideration of the apparatus before you; and to the detection and determination of the exact amount of carbonic acid contained in the air of this apartment.

This large tin vessel, called a gasometer, contains exactly 1 cubic foot and ½ of water. It is provided at its lower as well as at its upper part, with two apertures closed by stop-cocks. Now upon opening the stop-cock at the bottom, leaving that at the top closed, not one drop of water will flow out, just as you know in the case with a cask filled with wine or beer; the contents will not flow from an opening at the bottom as long as the upper part is perfectly closed and air-tight; but as soon as I open the upper stop-cock, together with the lower, the air immediately enters the vessel, and causes the water to flow out; and hence I have it completely in my power to regulate at will the rapidity of this efflux of the water, by opening more or less the upper aperture. It is quite obvious that in an apparatus like this, the amount of water flowing out at the bottom exactly corresponds to the amount of air entering at the top of the vessel; and that I, therefore, need only measure this water to obtain the exact measure of the volume of air investigated. But now you see that I have here put three small glass apparatuses into connexion with the upper stop-cock, so as to make the air of this room pass through them before it can enter into the large vessel; and you perceive also that the first and the last of these small apparatuses are filled with a coarsely-pulverized white substance (this is Chloride of Calcium,) whilst that in the middle contains a fluid (a solution of potass in water.) The first and the last are intended to retain all the moisture of the air passing through them, whilst the purpose of that in the middle is to imbibe the whole amount of carbonic acid contained in the air. Their weight is increased in this operation; and by the amount of this augmentation of weight, we can exactly and directly determine not only the amount of carbonic acid, but also that of water, contained in the air thus examined. The arrangement of the whole apparatus must satisfy you that any errors occurring in investigations of this kind can only arise from defects in the manner of weighing the apparatus with its contents, and may, therefore, be easily avoided by making use of a correct balance. I scarcely think that any further explanation is necessary to render the entire process intelligible to you, unless you require some further explanation as to the necessity of the deposition of moisture in the first and last apparatus, by the air which passes through them, for that the middle apparatus retains the carbonic acid of the air, only because the dissolved potass is a very powerful base, which combines with the carbonic acid, forming carbonate of potass, must be perfectly evident to you, without any further remark. Now, I told you that the first and the last apparatus are filled with Chloride of Calcium, which is a substance possessing an exceedingly powerful tendency to absorb water; the first apparatus completely retains all the moisture contained in the air passing through it. This apparatus has been carefully weighed previous to the commencement of the operation. The augmentation of its weight, after the completion of the process, therefore, tells me the exact amount of water contained in the air which has passed through it; and, as I stated before, the amount of this air is found by measuring the quantity of water which has flowed out. The carbonic acid passes untouched through this first apparatus, and is carried over with the air into the second apparatus, where it is completely absorbed by the solution of potass; the amount of the increase of weight in this apparatus, therefore, points out the amount of the carbonic acid contained in the air which has passed through. The last apparatus, which, as I have already stated, is also filled with Chloride of Calcium, and its weight exactly determined, serves as a kind of check, to ascertain whether the air, in passing through the second apparatus, has not imbibed, and carried over with it some water; since this circumstance (which may very easily occur) would render the result obtained altogether defective and fallacious; for should any water have been carried off, so as to

cause a decrease in the weight of the second apparatus, this would again be retained in the third, and its quantity determined from the increase of weight in the latter. In this case the sum total of the increase of weight in the two last apparatus, will give us the precise quantity of the carbonic acid.

We now come to the fourth essential constituent of atmospheric air, *i. e.* WATER; this is present in a gaseous state, or vapor, which differs from steam inasmuch as it is perfectly dry and transparent, whilst steam, being a mixture of vapor and liquid water, does not possess this dryness and transparency. When fluid water is present with vapor in a large proportion, it becomes completely moist and opaque, as all of you know is the case with mist, and with clouds. The invisible vapor of water is present in the atmosphere at all times and in all places, although, like carbonic acid, in very different and variable proportions, since its amount depends upon and varies with the temperature of the air, and with the presence or absence of water in its fluid state, which alone is capable of yielding vapor.

In general, you may assume that, *cæteris paribus*, the higher the temperature of the air, the *more* vapor, the lower the temperature, the *less* vapor it contains. It cannot, therefore, surprise us that warm air impregnated with vapor should, upon its refrigeration, deposit part of it in the form of fluid water. Whilst, on the other hand, an apparently very humid air may, upon a minute examination, yield a less amount of water than an apparently very dry air, provided the former be cold, and the latter warm. It will be easy to render evident the truth of this assertion by a few experiments.

The air of this room where so many individuals are breathing, and thus producing vapor, certainly contains a considerable amount of this gaseous substance, although the high temperature of the air prevents us from perceiving it. However, we need only cool a portion of this air, to know immediately that vapor is present, since it will manifest itself in the form of fluid water. For this purpose, I bring a decanter filled with cold spring water into the room; and what happens?—(you yourselves have observed this, doubtless, frequently)—the external surface of the decanter becomes covered with dew, which begins immediately to trickle down in the form of fluid water; obviously owing to the refrigeration of the atmospheric air surrounding the decanter, which on the lowering of the temperature, yields up a portion of its aqueous vapor condensed into water; thus revealing its presence. The same phenomenon becomes even still more manifest, if, instead of water alone, I fill the same decanter with a mixture of water, nitre, and sal-ammoniac, these substances will produce a temperature as low as about 12 degrees below zero of Reaumer's thermometer, which only gradually again rises. You see, indeed, that the moment I pour this mixture into the decanter, the outside of the latter becomes covered with dew; after a short time, this dew will become converted into a kind of hoar-frost, which gradually increases so as to form at last a complete snowy incrustation all round the decanter; this snowy incrustation afterwards, upon the decrease of the cold, forms itself into a complete crust of ice. These phenomena could not have occurred had there been no vapor present in the air of this room. These experiments, perhaps, might have been superseded, had I simply reminded you of the fact, that we constantly exhale from our own bodies a mixture of gaseous substances, containing a considerable amount of water in the form of invisible vapor, which remains invisible as long as the surrounding air is warm, but becomes immediately manifest as visible vapor whenever the air is cold; and the colder the air, the more palpable this vapor becomes.

Finally, with respect to the methods employed to determine, for scientific purposes, the amount of vapor in atmospheric air, they are very numerous. But the method which I have described, when treating of carbonic acid, is preferable to all the rest in the exactness of the results; and I have, therefore, no further remarks to add, except that, if we wish to ascertain the *amount* of watery vapor only in atmospheric air, it is, of course, sufficient to place a single apparatus filled with chloride of calcium into connexion with the upper stop-cock of the gasometer. The air, passing through, yields up its whole amount of aqueous vapor to the chloride of calcium, in the form of water; and thus permits the most exact determination of this amount by means of the balance, in the manner I have before described.

There remains now only the last of the essential constituents of the atmosphere to be spoken of, viz: AMMONIA; with the special consideration of which substance I shall conclude this lecture.

This glass tube which I hold in my hand contains *ammonia* in a pure state: I will endeavor to demonstrate to you its characteristic properties. You remark, in the first place, that ammonia is a gaseous and perfectly colorless substance; and you see that this moistened slip of blue paper (tinged with the coloring matter of the purple dahlia) when introduced into the tube, immediately assumes a lively green tint; and you know, from what I have already told you when explaining to you the meaning of the term *bases*, that this proves to us that ammonia is a *base*, soluble in water. The solubility of ammonia in water is very considerable, as I will show you by a direct experiment. I place the tube, which is now closed with mercury, over water; the water immediately ascends forcibly into it, the ammoniacal gas being eagerly imbibed by the water. I beg you to bear this fact in mind, as I shall afterwards have occasion to recur to it. Finally, ammoniacal gas possesses a highly characteristic pungent odor: of this you may satisfy yourselves by smelling to this flask, which is filled with a solution of ammonia. Most of you will recognize an old acquaintance in this smell, since you must have met with exactly the same kind in stables where horses or other animals are kept, or in the vicinity of dunghills. The pungency of ammonia in a very concentrated state is insupportable; and I may take this opportunity to remark, that a mixture of quick lime and sal-ammoniac, which evolves pure ammoniacal gas, has been denominated "*The Awakener of the Dead*," since people have frequently been recalled to life and consciousness, from a fainting fit, or from a state of suspended animation and apparent death, by applying the ammonia in this state to their nostrils. When I add to these remarks upon the properties of ammonia, that this subject is a chemical compound of nitrogen and hydrogen, I have told you nearly everything you need know respecting it for our present purpose.

But, you may ask, how can ammoniacal gas be an essential constituent of the atmosphere, if, notwithstanding the pungency of its odor, we are not able to smell it? The answer to this question is very obvious. If I place a drop of concentrated solution of ammonia in water, into this small platinum basin, and, placing the basin over a spirit-lamp, evaporate this drop, you see that not the slightest residue remains; and this will convince you that there is no solid substance present in the solution. The same occurs with this second fluid, into which I am now introducing a slip of blue paper; you see the paper turns *red*, a proof of the acidity of the fluid (it is hydrochloric, or muriatic acid;) a drop of it placed in the basin equally disappears without residue upon being heated. But now if I place a drop of the ammoniacal solution and a drop of the hydrochloric acid together in the platinum basin, you find, upon evaporation, that there remains a solid white substance, which is completely inodorous; it is a chemical combination of the hydrochloric acid with the ammonia, namely a *salt*, which all of you probably know under the name of *sal-ammoniac*. That ammonia is really present in this salt, I can immediately prove, by adding some lime, which, by exposure to the air has effloresced, or become slaked; this *base* combining with the hydrochloric acid of the sal-ammoniac, the ammonia is liberated, and manifests its presence by its pungent odor as well as by imparting a green tint to a moistened slip of blue paper held over it as it escapes.

If I now take two porcelain basins, of somewhat larger size than the platinum basin, both filled with chemically pure water, the addition of a drop of solution of ammonia to the water in the one, and of a drop of hydrochloric acid to that in the other basin, does not alter the result of evaporating either fluid; there remains *no residue*. If I evaporate separately the water containing the ammonia, and that containing the hydrochloric acid, both these substances will be imperceptibly carried off with the vapor of the water; being so highly diluted, their usual action upon reagent paper would completely fail, nor would any ammoniacal smell be perceptible. But if I intermix these fluids previous to evaporation, sal-ammoniac would be formed, a substance which does not volatilise at the boiling point of water, and therefore remains as a residue. The ammonia contained in this salt is easily detected in the manner I have already demonstrated to you, and even its amount may be determined by the balance.

But, I hear you ask again, What connexion have all these remarks with the ammonia contained in atmospheric air? Grant me your patient attention but one moment longer, and I shall immediately arrive at this point.

Imagine a confined amount of air, containing ammoniacal gas in admixture, but in such a minute proportion, that on account of its dilution, its usual reactions (*i. e.* its characteristic pungent odor, and its action on the blue reagent paper) altogether fail; you will understand that from the great tendency of ammoniacal gas to dissolve in water, I am able to bind this ammonia *to* water by agitating *with* water the air in which it is contained in admixture. Indeed, even when thus dissolved in water, its minute proportion still prevents its being detected by the usual reactions. By the addition of hydrochloric acid, however, I can produce an ammoniacal salt (sal-ammoniac,) which remains as a residue upon evaporating the water, and is the means of determining the proportionate amount of ammonia in the atmosphere. But the amount of ammonia in the atmosphere is so very minute, that were I to perform the process just now described, I could hardly expect any correct result, unless I made my experiment upon enormous quantities of air, which would be a matter of considerable difficulty. But there are certain processes in nature which save the chemist all this trouble and labor, and have, moreover, the advantage of presenting the ammonia contained in a very large quantity of air, dissolved, without any labor on his part, in a proportionately small amount of water. These processes are the formation of rain and snow. Ammonia has invariably been detected in rain water, and in snow, whenever care has been taken to add to these substances some hydrochloric acid, previous to evaporation, and thus to cause the formation of sal-ammoniac. The most decisive experiments have been made for this purpose by many chemists, and other natural philosophers, and invariably with the same result.

It will now be intelligible to you upon what grounds we consider ammonia to be an *essential* constituent of the atmosphere; and you will also understand the reason why, in former times, it might be so easily overlooked in investigations into the composition and constitution of the air.

I think, moreover, I have now answered satisfactorily your question, "Why the ammonia in the air is not perceptible to our sense of smell?" so that there remains nothing but to conclude my lecture. However, before we separate, permit me to call your attention to what has taken place in the meanwhile with the tumbler, which, as you will recollect, I filled to the brim with carbonic acid, and put aside. You see I now introduce a lighted taper, and it continues to burn with a steady flame; this proves to you that the carbonic acid is no longer present in the tumbler, and that, notwithstanding its greater specific gravity, it has been displaced by the far lighter atmospheric air. I shall have occasion, in my next lecture, to apply the result of this experiment to the explanation of that natural law which insures the intermixture of all gaseous bodies.

LECTURE III.

THE ATMOSPHERE.—(CONTINUATION.)

Investigation into the Origin of the Constituents of the Atmosphere.... Its Non-Essential Constituents.... Diffusion of Gases.

WERE I to inquire of you, Gentlemen, whence you suppose all the water has been derived, which, in the comparatively short period of your lives, has fallen in the form of rain or snow from the atmosphere, every one of you would answer, that this water had previously entered the air in the form of vapor, owing to the process of evaporation going on incessantly from brooks, rivers, lakes, seas, and moist soils; that under certain favorable circumstances it formed clouds, and again returned to the surface of our earth in the form of rain or snow, in order to pass through the same varying phases of this rotation incessantly. For that this water should have originated in the air, or should have entered our atmosphere from the free space of the universe, will appear improbable, to any one who has ever taken the trouble to observe the process of drying any moistened surface, or the gradual disappearance of any mass of fluid water exposed in an open vessel to the air; since it is easy to imagine that the same process takes place with every surface of water so exposed, and thus to form a correct opinion as to the origin of rain and snow water. Natural philosophy, chemistry, and meteorology, have arrived at the same conclusion by means of the most minute observations, and the most comprehensive calculations.

Thus, that which the more intelligent part of the public universally consider to be the probable source of the water in the atmosphere, exactly agrees with the results of scientific investigation; and I might dismiss this matter very summarily, were this the case also with respect to the other constituents of the atmosphere. But it is not so; and I must, therefore, first examine and discuss the origin of the several constituents of the atmosphere, before entering upon the consideration of other subjects. The investigation of this matter will not merely tend to facilitate your comprehension of my future lectures, but will also afford you an insight into the harmony of creation, and that Sublime Wisdom to which this harmony is owing: and will furnish you, perhaps, with a more vivid impression, a deeper insight into that wisdom, than can be derived from any other department of natural science.

If you will bear in mind, Gentlemen, that OXYGEN is absolutely necessary for the support of the life of man and animals, as well as for sustaining innumerable processes of combustion (for all animals would die, and every flame and light would be extinguished immediately, were the atmosphere deprived of its oxygen,) and that, nevertheless, the amount of oxygen in the air remains constantly and invariably the same; the question will very naturally occur to you, How is this oxygen reproduced? Whence is that necessary and constant supply? The solution of these questions belongs properly to the chemist, since he ought to be best and most exactly acquainted with the various modes of the production and preparation of oxygen. The question in itself will appear superfluous, only if we admit the supposition that the *creation* of elements is still continuing; for, in that case, the inquiry would be at an end, and the subject placed altogether beyond the domain of scientific research, by the simple statement of the fact that *it is produced.* There exists, however, not one single fact of any scientific value, to support such a notion; it is, therefore, most rational to leave it altogether out of the question, and exclusively to listen to chemical experience.

The science of Chemistry possesses a great many methods of producing oxygen; among all these methods, however, there is but one which can guide us in ascertaining the origin of the oxygen in the atmosphere, because it is obviously the same method which Nature constantly employs to cover the enormous consumption of atmospheric oxygen, by its reproduction. This method of producing oxygen, which the chemist pursues upon a small scale in his laboratory, Nature employs on a grand one in her magnificent operations; unless, indeed, the chemist prefers other methods on account of their greater degree of rapidity and convenience. This depends simply upon the decomposition of water by living plants

under the influence of light, carbonic acid being present; by which process of decomposition, the oxygen, which, as I have already stated, exists in the water in combination with hydrogen, is separated and yielded up to the atmosphere. This process of the separation of oxygen from water, by living plants, has been understood for a very long time; but that the absorption of carbonic acid is the cause of the separation of the oxygen, may perhaps not be so generally known. I will, therefore, communicate to you an experiment which I made with regard to this point.

I took a glass flask filled with pure water, and put a few fresh geranium-leaves into it; I then placed the flask in an inverted position, into a flat vessel, also equally filled with water, so that neither the water could run out, nor any air enter the flask. Nevertheless, after the lapse of a short time, an immense number of small bubbles of air formed upon the surface of the leaves; which, gradually increasing in size, at length left the leaves, ascended through the water, and formed at the upper part of the flask, one bubble of a larger size. This evolution of gas was manifestly accelerated when I placed the flask in the sunshine. The bubble upon examination was found to consist of pure oxygen gas. After the lapse of not quite two days, the evolution of oxygen ceased; from this we must infer that the leaves in *themselves* (which we must consider to be *living* as long as they are fresh) are deficient in that condition upon which their property of separating oxygen depends. Now, upon adding a few bubbles of carbonic acid to the water of the flask, the evolution of oxygen immediately recommenced; on the third day of the experiment it stopped again, but recommenced upon some more carbonic acid being added. I was obliged to discontinue the experiment upon the fourth day, as the leaves were then beginning to fade. Many similar experiments have, however, been made by chemists, and invariably with the same result. I do not precisely know, Gentlemen, whether the conclusion deduced from these experiments, namely, that it is the carbonic acid which causes the evolution of the oxygen in this process, will appear quite satisfactory to you. I can, however, assure you that it is impossible, at present, to give a better explanation of the separation of the oxygen in this operation; and whatever you may think of the process itself, it must be acknowledged to be a rich source of oxygen, deriving a still higher importance from the fact that vegetation under the influence of light is the only process employed by Nature for the reproduction of that important element.

With regard to Nitrogen, the inquiry into the origin of this constituent of the atmosphere may be said to merge into a general one, as to the original formation of the elements. Taking into consideration the passive condition of this substance, that is, its feeble participation even in the artificial processes of the laboratory, (although according to the evidence of chemists, these are more manifold and varied *there* than in the economy of nature, since a number of nitrogen compounds which do not exist in nature, are yet frequently produced in the chemical laboratory, though in a very elaborate manner,) we may at once admit the supposition that we probably shall not be able to detect processes occurring on a large scale in which the amount of nitrogen contained in the atmosphere is decreased, by chemically combining with other substances. And indeed this supposition, which is based upon the general properties of nitrogen, receives a positive character, when, looking round in nature for any such processes, we perceive none. The only process in nature which might be here adduced is the formation of nitric acid in the air by flashes of lightning passing through it; this is, however, of very secondary importance compared to the formation of those infinitely large quantities of the same acid, in the production of which the nitrogen of the atmosphere has not the slightest share, according to the investigations and experiments of one of the best French chemists (Gay-Lussac) and others;* I mention this, at this time, only *en passant*, in order to avoid being reproached with having willingly concealed from you a fact which may appear, at first sight, to militate against my views.

We can discover no process in nature by which the amount of nitrogen in the atmosphere can be materially decreased; nor is there, to our knowledge, on the

* The allusion in the text is to the formation of nitrate of potass in the soil in the East Indies, and elsewhere. The nitrogen of this salt has been proved to be derived from the decay of nitrogenized matters present, or, according to Liebig, to the oxidation and absorption of ammonia during the decay of organic matter.

other hand, any process in nature tending to its augmentation; the combustion of nitrogenous organic substances, which certainly is capable of yielding nitrogen, is but very insignificant, and may be rightly considered as a means of replacing that portion of the nitrogen, which the formation of nitric acid, during thunder-storms, withdraws from the air. We must, therefore, suppose the amount of nitrogen in the atmosphere to be definite and invariable; and all scientific investigations hitherto made, support this opinion. This permanency in the amount of nitrogen in the atmosphere, once admitted, and taking into consideration that there is good reason to believe that the same has been the case in the past, and will be equally so in the future, you will understand, Gentlemen, why the inquiry for the manner in which nitrogen came into the atmosphere, is one and the same with that respecting the original formation of this element; and that, knowing nothing certain with regard to the formation of the other elements composing the materials of which our planet is made up, we are also completely in the dark with respect to the original formation of nitrogen: all we know of the matter is, that the nitrogen *is present* in the atmosphere, because *it existed in it from the very beginning*.

We now turn to the CARBONIC ACID; and here we must first endeavor to answer the question, whether we can discover any process in nature tending to explain, not so much the presence of carbonic acid as its constant supply, or restitution to the atmosphere. For since (as I intend to demonstrate on a future occasion,) there are certain processes continually going forward in nature calculated to deprive the atmosphere of its carbonic acid, it is very natural that we should examine whence the atmosphere derives a constant supply of this essential constituent, so as to balance its consumption. This supply comes from various quarters. I will not, however, enter here into a minute exposition and development of the various natural processes for the production of carbonic acid, but will content myself with merely mentioning them by name: these processes are—the respiration of man and animals; the combustion of carbonaceous substances, such as charcoal, wood, &c.; fermentation and decomposition (or disorganization) of organic bodies; and the emission of volcanoes. All these processes yield a rich supply of carbonic acid to the atmosphere.* The number of these processes, and, still more, their magnitude and extent, which, without my endeavoring to load your memory with figures, will appear to you considerable enough to prove that there must exist a very energetic process, which, by constantly withdrawing carbonic acid from the atmosphere, serves to counterbalance this enormous supply, and to prevent its undue accumulation. And if you reflect upon the fact that this carbonic acid in most cases is formed at the expense of the atmospheric oxygen (as is the case especially in respiration, combustion, and the decomposition of organic substances), you will easily comprehend that the process counteracting this accumulation of carbonic acid in the atmosphere cannot be confined to the mere withdrawal of this substance from the air, but that at the same time a reproduction of oxygen must take place, if the equilibrium, or proportion between the constituents of the atmosphere, is to be preserved; that is, if the atmosphere is to retain its *least* normal amount of carbonic acid, and its *greatest* normal amount of oxygen. It is probable, as I have already demonstrated to you, that the consumption of carbonic acid and the production of oxygen in the great laboratory of Nature are effected only by vegetation—by the living energy of plants under the influence of light. It will not, therefore, surprise you to hear me describe the life of the vegetable world as that process which renders the accumulation of carbonic acid in the atmosphere impossible, and, at the same time, assert that it is the means of maintaining its proper proportional amount of oxygen. It is to this mutual relation between the vegetable and animal kingdoms, that I desire to call your particular attention; since this will tend to afford you a certain insight into the infinitely judicious arrangement of the great household of Nature; and whenever, in the course of these lectures,

* The reader may form some idea of the enormous amount of carbonic acid yielded to the atmosphere, by considering that upwards of two millions of tons of coals are consumed annually in the English metropolis, and its suburbs, the combustion of which requires more than double that amount of oxygen. To this must be added, the carbonic acid produced by the burning of tallow, wax, oil, and other substances. And again, in the same area, that is, a circle with a diameter of not more than 10 miles, there are 2,000,000 of human beings, each on an average yielding four pounds of carbonic acid daily to the atmosphere. Of horses and other animals at least half a million must be reckoned. The lowest estimated amount of carbonic acid thus supplied to the atmosphere by London and its environs will exceed 10,000,000 tons annually.

you may feel disinclined to listen attentively to my remarks and explanations—perhaps because you find it difficult to comprehend entirely new truths, or, perhaps, because you cannot readily abandon your old and cherished prejudices—let me entreat you to recal to your minds this indication of Infinite Wisdom in the arrangements of Nature; and from this recollection to gather courage to combat your disinclination for study, or to surrender your prejudices until you have attained conviction of the truth; and this in a SCIENTIFIC FORM, and supported by SCIENTIFIC EVIDENCE.

In conclusion, permit me to remark, with regard to the proportional amount of carbonic acid in the atmosphere, that in all probability it was far richer in carbonic acid, and far poorer in oxygen, in those remote periods of the earth's history, studied only by the Geologist: and taking, of course, some other circumstances into consideration, this fact fully explains the existence of the collossal flora of the primeval world, on the one hand, and the non-existence of those species of animals which require for their sustenance an atmosphere rich in oxygen, on the other. These are phenomena which have long since been understood as scientific facts. The carbon of this primeval carbonic acid, laid up in the strata of the earth in the form of Anthracite, and other varieties of fossil coal, proves at the present time as advantageous to us as the oxygen separated during the existence of the primeval flora, with which our atmosphere has been gradually enriched. But these observations belong rather to another science, and I must therefore, for more extensive and minute information on this highly interesting subject, refer you to works on Geology.*

I now come to AMMONIA, and I shall also endeavor to demonstrate to you the origin of this constituent of the atmosphere, although you must permit me here to pre-suppose as known, some matters, into the explanation of which we shall subsequently have occasion to enter more minutely; viz. the process of putrefaction, or decomposition of organic, and especially of animal bodies. If we inquire of the Chemist what are the possible sources of that gaseus compound of nitrogen and hydrogen, denominated Ammonia? He will tell us that there are a considerable number of them; but none of these are sufficient to explain the formation of ammonia in the great economy of nature, with the exception of the putrefaction and decomposition of nitrogenious substances.

Owing to these processes of decomposition, especially of animal substances, exceedingly large quantities of ammonia are constantly produced, and, intermixing with the atmosphere, admit of easy detection, in all cases where the air in the immediate vicinity of decaying organic, and especially animal substances, is tested for its presence; indeed, our sense of smell is quite adequate to detect the mere presence of ammonia in the air; and when a determination of the exact quantity of this substance present is not required, it is in itself sufficient. I can confirm the correctness of this assertion by an illustration taken from the sphere of your own experience.

Certainly, Gentlemen, all of you will have been struck with that characteristic odor which you perceive upon visiting your stables, and which makes your eyes water; and, had you upon one of these visits taken a slip of blue Georgina paper with you, you would have found it assuming a green tint after the lapse of a very short time. You may make this experiment for your own satisfaction at any time; I must, however, remark that ammonia being a volatile substance, the green tint disappears in the open air. The air in the stable possesses the property of affecting your sense of smell, your eyes, and your blue paper, only from the amount of ammonia it contains; and which in the stable is more considerable than outside, in the free air. And when I tell you that no animal substance is capable of forming larger quantities of ammonia, during its putrefaction and decomposition, than urine, it will not by any means surprise you that the air of your stables should be so rich in ammonia. The air in stables is constantly displaced and replaced by fresh air, which in its turn becomes also charged with ammonia, because the process of decomposition of animal substances, and especially of urine, giving rise to the formation of ammonia is constantly going on there.

I will take this opportunity of furnishing you with a very simple method of fixing the greater proportion of the ammonia in the air of your stables, so as to

* Phillips's Geology, in Two Vols. fcap. 8vo. of Lardner's "Cabinet Cyclopædia," is well suited to those who wish to pursue this subject.

prevent its escaping and being lost in the external atmosphere. I shall have occasion hereafter, when treating of manures, to demonstrate the importance of preserving the ammonia, if you wish to benefit your crops by the nitrogen of stable urine. You have only to place some flat vessels filled with hydrochloric acid in the stables, and the ammonia, being an alkaline substance, or base, will be absorbed by the hydrochloric aid, and form hydrochlorate of ammonia, that is sal-ammoniac.

Let me illustrate this by an experiment.—I have here a bell-glass, to which the atmospheric air of this apartment has free access. To convert the air contained in this glass into stable air, that is, into an air containing more ammonia than is usual in the atmosphere, I need only place the bell-glass over something whence ammonia is exhaling. I take a small platinum basin, containing a solution of ammonia; the ammonia evaporates spontaneously from this; if I place it under the bell-glass for a few minutes, the confined air is converted into air precisely like that of a stable, as you may perceive by the smell, or by testing it with dahlia paper. I take another small platinum basin filled with hydrochloric acid; if I now place this under the bell-glass, you will immediately perceive the formation of a white crust around the brim of the basin.

I will first evaporate a small portion of hydrochloric acid, which has not been exposed to the air of the bell-glass. You see it leaves no residue—it contains no sal-ammoniac. Now, if I evaporate the contents of the basin which has been under the bell-glass, you see a white inodorous salt remains; this is sal-ammoniac, and I need only rub this together with lime, to evolve pure ammoniacal gas.

When we reflect upon the extent to which the processes of putrefaction, not only of the excretions of man and animals, but also of the entire bodies of animals and of men, and of the decay of plants, are ever proceeding, and calculate the enormous quantities of ammonia these natural processes must necessarily have produced during thousands of years, and compare with this the comparatively minute amount of ammonia, which is found present at any time in the atmosphere, or in rain-water and snow, the conviction is forced upon us, that there must be some cause, powerfully and continually counteracting the accumulation of ammonia. But we are not able to discover in nature any process for fixing ammonia similar to that I have just employed in my experiment, by the formation of a non-volatile ammoniacal salt. We need not, indeed, seek for such a process, since we nowhere meet with its necessary product, that is, the ammoniacal salt; we are compelled, therefore, to conclude that the process employed by nature for fixing the ammonia of the atmosphere depends upon a different principle. What the real nature of that process is, I cannot at present explain to you without disturbing the systematic arrangement of my lectures, and exposing myself to the risk of being misunderstood. I shall, however, in the second part of these lectures, give you the necessary information upon this point; for the present it is sufficient that you should know that such a process *must necessarily exist.*

Having thus discussed with sufficient fulness the *essential* constituents of the atmosphere, I will add a few words only respecting some merely accidental constituents, that is, substances which are sometimes, but not always and everywhere found in the air, contenting myself with furnishing you with the names of the principal of them, the places where they are found, and the manner of their formation, since any more minute information on this point would be altogether useless for our present purpose.

These accidental constituents are—1st, *Dust.* This is more especially found in the atmosphere after a long continuance of dry weather. 2nd, *Nitric Acid.* This is present in the air after thunder-storms. 3d. *The constituents of sea-water* are found in the air near the sea-coast, especially after hurricanes blowing inland from the sea. 4th. Certain gaseous *compounds of Carbon, Sulphur, or Phosphorus, with Hydrogen;* are met with in the vicinity of marshes, swamps, stagnant water, &c. These are all we need mention.

Let me now say a few words respecting the Diffusion of Gases.

By *diffusion* we understand that property of gaseous bodies to intermix uniformly or become completely diffused through each other, even in such cases where we should deem it impossible, were we not assured of the fact. In this property they differ entirely from liquids, as I will proceed to show you by a few experiments.

The glass flask I hold in my hand contains two different liquids, a blue and a colorless one; the blue fluid at the bottom is a solution of sulphate of copper, the colorless fluid is pure water, which, as you see, floats upon the blue fluid, because it is specifically lighter. Here the familiar instance of oil and water will occur to you; the difference in the specific gravity of these fluids prevents their intermixing. You know, Gentlemen, that liquids arrange themselves according to their densities, the heaviest beneath, the lightest uppermost.

But it is altogether different with gaseous substances. You will, no doubt, recollect the experiments made in my last lecture, to demonstrate to you that carbonic acid is heavier than atmospheric air, and you will remember that, amongst other experiments, I filled a tumbler with carbonic acid, and placed it aside. Knowing that carbonic acid is far heavier than atmospheric air, you might reasonably have expected that the carbonic acid would remain in the tumbler, and yet, when looking for it after the lapse of half an hour, it was completely gone; a lighted taper placed inside the tumbler continued to burn with a steady flame, and had we taken the trouble to analyse the air in the tumbler, we should have found it contained no greater amount of carbonic acid than the air in the apartment.

Thus a complete intermixture had taken place, notwithstanding the great difference between the specific gravity of carbonic acid and atmospheric air.

You must not imagine, Gentlemen, that this tendency to intermix,—a tendency so different to what we find with respect to liquids, is confined to the single instance of carbonic acid and atmospheric air. On the contrary, the same thing appears with all gaseous bodies, without exception; it must, therefore, be understood by you to be a positive law for gases.

I scarcely need tell you the reason why I have made these experiments, and am so desirous of making you understand this property of gases to intermix, and to become diffused throughout each other, as you will probably at once perceive that it was to impress upon your minds the cause of the perfect intermixture of the several constituents of the *atmosphere*, notwithstanding the difference in their specific gravities. Unless I had made you acquainted with this law of gaseous substances, you might perhaps have conjectured that the various atmospheric currents—the winds—were the cause of that perfect intermixture; but you will *now* know that, although the minds may serve to accelerate it, it would certainly take place without their assistance.

The importance of this property of the gases to the welfare of all living beings, is too obvious to need any lengthened remarks. It is owing to this property that all organized, living creatures find, at all times, and in all places, in the atmosphere, that constituent upon which their existence depends; on the other hand, it altogether prevents the accumulation of any one element in particular places, the too great abundance of which would be injurious, and thus we must acknowledge, that this apparently insignificant property of gaseous bodies, is a necessary condition of animal and vegetable life.

LECTURE IV.

ON WATER.

Chemically pure Water—its constituents....Water as a solvent for many substances....Rain Water....The Water of Springs—Rivers....Sea Water....Well Water.

WATER is a compound substance; it is a chemical combination of two gaseous bodies—oxygen and hydrogen. The science of Chemistry enables us to combine oxygen and hydrogen, and thus to produce water artificially. On the other hand, it teaches us how to separate its constituents from each other—that is, to decompose it. The apparatus you see around me is introduced here for the purpose of showing you, by a few experiments, the formation and decomposition of water.—Before, however, entering upon these experiments, permit me, Gentlemen, to offer you a few preliminary remarks upon one of the constituents of water, of which

we have not yet spoken—namely, HYDROGEN—as many of you may not be acquainted with its properties.

The name of this substance refers to its forming water when combined with oxygen; it is derived from ὕδωρ, *water*, and γεννάω, *I generate*. Hydrogen is a gaseous body like oxygen, nitrogen, &c., but it differs from these and from all other elements (chemists designate by the term "*element*" all those bodies which they are unable to decompose, and which must, therefore, be considered *simple* bodies—about fifty-six such simple bodies are at present known,) by its specific gravity being fourteen times lighter than atmospheric air; and it is further characterized by its tendency to combine with oxygen, producing flame—whence it is also denominated inflammable air—whilst it is not capable of supporting the combustion of other bodies. I have here a small gasometer filled with hydrogen gas; I allow a small portion to escape into this little balloon, so as to inflate it; you see it ascends rapidly in the atmosphere; this proves to you the very great lightness of hydrogen. I introduce into this small glass tube filled with hydrogen, a kindled splinter of wood; you see it ceases to burn—this is conclusive that hydrogen will not support combustion. If I fill the same glass tube again with the gas, and, keeping its aperture downwards, approach a lighted taper to it, you see that the hydrogen ignites; and, upon turning the aperture upwards, so as to allow the hydrogen to escape, and thus to have free access to the oxygen of the atmosphere, it burns with a feebly luminous flame.

We now return to the principal subject of our present lecture—namely, WATER; and let me, in the first place, call your attention to the apparatus before you, and to the phenomenon which you perceive at this moment proceeding in part of it.

This apparatus is for the decomposition of water into its two constituent elements. It consists of a galvanic battery—galvanism being the means we employ for the purpose of decomposing the water—and, as you perceive, two glass tubes placed in such a manner as to receive and measure the product of the decomposition. We omit all considerations respecting the construction of the galvanic battery, and the means of conducting the galvanic current into the water of the glass tubes, as this would divert us too far from our subject, and confine our attention to what is occurring within the glass tubes. You see an immense number of the most minute bubbles of gas ascending through the water in both tubes, and collecting at their upper extremities. It will not escape your attention that these bubbles proceed from a wire, one extremity of which reaches into the water of the tube, the other being connected by an appropriate contrivance with the galvanic battery. The wire of the one tube being connected with the copper plate, that of the other with the zinc plate of the battery. If you compare the amount of the gas which has collected at the upper part of one tube with that at the upper part of the other tube, you will find that one is only half as great as the other. Upon subsequently interrupting this process of decomposition, and examining these gases, we shall find that the least bulky is pure oxygen, whilst the other is pure hydrogen.

This experiment not only demonstrates to you that water may be decomposed and separated into two constituents, but it shews you the manner in which these component parts of the water may be collected separately for examination; and, moreover, they furnish you with a conclusive proof that water is a combination of oxygen and hydrogen in the proportion of *one* of the former to *two* of the latter—that is, by measure or volume, (it is not so by weight.) The next experiment I shall exhibit to you, and which has for its object the formation of water, will afford an additional proof of the correctness of this conclusion respecting the proportion of the two elements. This instrument is the Eudiometer, which I have already employed to determine the amount of oxygen in the atmosphere, and which, doubtless, you recognize. I introduce into it oxygen gas; and, by the exact measurement which the graduation of the tube enables me to make, I find I have 110 volumes of oxygen. I now introduce hydrogen, and, by observing the space now occupied by the mixed gases, I find that it amounts to 415 volumes; consequently, I have in the Eudiometer 110 volumes of oxygen and 305 volumes of hydrogen. You know already, from my former experiment with the Eudiometer, that a mixture of oxygen and hydrogen may be exploded with vivid ignition by transmitting through it an electric spark. I prefer, however,

at this time, to effect the combustion of the gases by means of a piece of spongy platinum, in order to acquaint you with this method. Spongy platinum is used in a common instrument for obtaining an instantaneous light, by directing on it a stream of hydrogen. I introduce a piece of spongy platinum into the Eudiometer, by pushing it under the mercury; it ascends through the mercury, rises to its surface, and comes into contact with the gaseous mixture; immediately you see the volume of the mixture diminish, and the mercury ascends into the tube; this is a proof that a space has been created. The combination of the gases proceeds less rapidly by the influence of the spongy platinum than by the electric spark, but not less surely. The platinum itself becomes red-hot in the process. You see, moreover, the inside of the tube is covered with the product of the chemical combination of the oxygen and hydrogen—namely water—in the form of dew. Upon measuring the gas still remaining in the tube, we find that it occupies only eighty-five volumes. Were we to examine this residuary gas, we should find it to consist of pure hydrogen; hence it follows that 220 of the 330 volumes of the gaseous mixture (415—85=330) which have disappeared were hydrogen.

You see here, again, that water can be formed of oxygen and hydrogen only in the proportion of 1 : 2 (=110 : 220.) I, therefore, think that there can remain no doubt upon your minds with respect to this fact, so fully and scientifically proved.

The water formed in this manner is chemically pure water. This may be prepared upon a larger scale; but, of course, by other means than the Eudiometer.

But water never occurs in nature in a state of absolute purity; it invariably contains extraneous matters mixed with it. I deem it, therefore, important that I should separately describe the several kinds of water occurring in nature, and which differ from each other according to the various matters they contain in admixture. I shall hereafter, when treating of the soil, have occasion to shew you the necessity for this separate consideration of different waters.

Before entering upon a chemical examination of the differences in the several kinds of water, (we disregard altogether physical differences,) I must make a few remarks upon a general property of water, upon which these varieties in its chemical character depend—namely, that property which water possesses of dissolving various gaseous, liquid and solid substances. The substances thus dissolved impart to the solvent certain properties, varying, of course, according to the nature of. the individual substance or substances dissolved. These imparted properties distinguish the various waters occurring in nature from chemically pure water, and render them suitable for the performance of divers and highly important purposes.

You are sufficiently acquainted with the power of water to dissolve many solid substances, converting them into a state of fluidity. You all know that many salts are soluble in water, and you certainly are well aware that many fluids equally mix with and are absorbed by water; but you may not probably be possessed of the information that water maintains the same deportment towards all gaseous substances, without exception. Water absorbs all gases, though in various proportions, but with this peculiarity, that it absorbs the greater proportional amount, the lower its temperature. In the solution of solid substances it is just the reverse—the higher the temperature of the water, the more it will dissolve, with a few rare exceptions.

You will not, consequently, be surprised to discover, upon minute investigation, that water invariably contains the constituents of the atmosphere, and you will observe that this impregnation of water with atmospheric constituents imparts to it certain properties—that is, it enables it to exhibit certain phenomena which chemically pure water never produces. Thus, for instance, carbonate of lime is insoluble in pure water, whilst water containing carbonic acid (one of the constituents of the atmosphere) in solution, dissolves it readily, and the more copiously the more carbonic acid it contains. In the next lecture, I shall have occasion to revert to this subject. I will now proceed to the consideration of the varieties in the chemical character of the waters found in nature, beginning with rain-water and snow-water.

If you will recollect what I told you, Gentlemen, in a former lecture respecting the several constituents of the atmosphere, together with the property of

water to absorb gaseous substances, which I have just mentioned, you will at once perceive how probable it is that, if you test rain or snow-water for extraneous substances, you will meet with some of the constituents of atmospheric air, since rain and snow, whilst falling through the air, have abundant time, and are in favorable circumstances, for the absorption of its constituents. And this is found to be invariably the case: oxygen in a gaseous state, nitrogen, carbonic acid and ammonia have, upon a careful examination, always been found in rain and snow-water. We may, therefore, consider these dissolved gases as necessarily pertaining to this kind of water; whilst nitric acid, which is found in the rain which falls during thunder-storms, must be deemed an accidental ingredient, because it is absent from ordinary rain-water. It is the same, with a gray or black matter, which is left when we evaporate rain or snow-water, since this is nothing more than dust, which was mechanically suspended in the air, and carried down by the rain or snow. This admixture of dust is found most copiously in the rain or snow which first falls after dry weather, and especially when such weather has prevailed for any length of time. All other extraneous substances found in rain-water, in particular localities, require no especial attention, their presence being merely accidental. Thus, amongst the essential constituents of rain-water, there is no solid substance which would give us any residue upon evaporation, and, therefore, when in chemical books you find rain-water designated *pure*, recollect it is in reference to the absence of solid matters.

It is altogether different with respect to spring and river waters. We invariably discover in these, by proper examination, solid substances, together with the constituents of atmospheric air, in solution: in spring-water especially, besides the constituents of atmospheric air, generally, and carbonic acid more particularly, a number of salts are held in solution, which upon evaporation, remain and form a kind of rocky incrustation upon the surface of the evaporating-dish: that is, if we employ the same dish for evaporating successive quanties of the water, without removing the deposit.

We need not look very far to discover the origin of the solid constituents of spring-water, if we reflect upon the source of springs. The water which precipitates from the atmosphere in the form of mist, especially upon elevated lands and mountains, (and which has the same properties as rain-water, its mode of formation being the same,) runs partly down the surface of the mountains and rocky masses, forming brooks and rivulets, and partly trickles through their clefts and fissures, reäppearing again in the form of springs at lower elevations. During this slow process of trickling through the mountain masses, the water, already impregnated with the constituents of the atmosphere, dissolves and carries away in solution a number of salts; differing of course in different localities, in number and kind, according to the nature of the rocks and soil through which the water slowly percolates. Spring-water, therefore, in a chemical point of view, must be considered as rain-water with solid substances in solution. It is called *hard-water*, and it differs from river-water, termed *soft-water*, from its containing a larger proportion of solid and gaseous substances in solution than the latter. The bubbling, or pearling of spring-water when first drawn from its source, is owing to the gaseous substances it holds in solution. "What, (you may perhaps exclaim,) do you consider spring-water less chemically pure than river-water, and yet rivers are produced from springs?" Indeed, Gentlemen, the water of springs flows into rivers, but the water of innumerable brooks and rivulets, rain and snow-water, also flow into the rivers and dilute the spring-water to such an extent, that most of the salts which may perhaps be detected in as little as half an ounce of spring-water, can no longer be traced in river-water, unless we concentrate by evaporation many pounds, or even hundred-weights of it.

If you take into consideration that the water of brooks and rivulets mostly flows rapidly over the surface of the earth, having no time to dissolve much solid matter, and consider the process of dilution which spring-water undergoes, you will see the reason why river water should contain so small a proportion of solid substances. We disregard here, of course, all substances which may be mechanically mixed with, and suspended in, these waters; such substances may be separated by a mechanical process, namely, filtration. The chemist finds but rarely any difference save that of magnitude between the huge stone block rolled

along by the mountain-torrent, and the finest particles deposited from even perfectly clear river-water, after standing many days at rest, in the form of mud.

All the water of the surface of the earth flows at last into the sea, (excepting, of course, that which evaporates on its way thither,) carrying with it all the gaseous and solid substances which it contains, in solution; depositing in its course, or immediately on reaching the sea, all substances which are only mechanically admixed with it. The causes of this are not for our present consideration. Now, as a very large amount of water is constantly evaporating from the surface of the sea, whilst the salts contained in it remain, you will perceive that the sea in the course of time must become more and more impregnated with salt. This will happen the more speedily the smaller the sea—the more rapidly the evaporation proceeds, the larger the rivers and streams are which pour their water into it, and the more saline their waters were originally. Sea-water, therefore, differs from river-water, not essentially, but only in degree, that is, by its larger amount of saline contents; we may, therefore, readily conceive that a salt water sea or lake may be formed by river-water gathering into a deep excavation of the earth, whence it cannot flow off, but is subject to rapid evaporation. I could point out to you, did our time permit, many such seas or lakes, which have evidently been formed in this manner; it may suffice to mention the Caspian Sea, the Dead Sea, the Elton and other Lakes. I regret that sea-water does not come within the range of subjects to which we may devote a particular and minute attention; since I think that I should be able, with the aid of geognostical observations and geological inferences, to make it appear probable to you, that a part of the saline matter contained in the sea, is, from time to time, restored to the solid earth by volcanic agency, and that in this respect also, there is an eternal circulation of matter going on in nature, just as we have seen to be the case with water, and with the constituents of the atmosphere. The latter point, which I have already spoken of in the preceding lecture, will be more fully proved and illustrated hereafter.

Before entering upon the consideration of any new topic, let me bestow a moment's attention upon carbonic acid, as a constituent of water, and especially of spring-water, since its presence in water is the cause of some highly important phenomena. I have already to-day called your attention to the circumstance, that the presence of carbonic acid in water, enables it to dissolve certain substances, insoluble in pure water; and, as a remarkable instance, I mentioned Carbonate of Lime, to this I will now add Carbonate of Magnesia, and Protocarbonate of Iron. Now, as these three substances, but more especially the Carbonate of Lime, are found almost everywhere in the soil, it is not surprising that they should almost invariably be found in spring and well-water, since such water invariably contains carbonic acid; and their proportional amount is the greater, the more the carbonic acid that is contained in the water. And I must further inform you, that carbonic acid gas dissolves in water, the more copiously, the lower the temperature of the water, and the greater the pressure under which the solution is effected; and as the temperature of the water rises, or the pressure is taken off, the carbonic acid escapes, in its gaseous form, from its solution. All those substances, therefore, which were kept in solution by the presence of carbonic acid, ceasing to be soluble in water when the carbonic acid has escaped, precipitate from it, and not unfrequently form calcareous or ferruginous incrustations upon the surfaces of certain bodies, stones, fragments of wood, &c. lying at the bottom of springs of this description, or in the bed of brooks and rivulets formed by springs. You are all acquainted with these petrifactions, as they are called.

In all springs, wherever they may be situated, the pressure upon the surface of the water is diminished upon its reaching the surface, and in most cases the temperature of the atmosphere is higher than below the surface; carbonic acid, therefore, separates as gas, and we need not be surprised that river-water should, and does, contain a less amount of such substances as are rendered soluble by the presence of carbonic acid than spring-water. This circumstance must be taken into consideration when we are examining it, with a view to discover the amount of lime which it contains.

In conclusion, Gentlemen, permit me to furnish you with a table, indicating, at least approximatively, the proportional amount of solid saline matter contained

in several varieties of water. Many experiments to determine this amount have been made by myself and other chemists, and the results are stated in round numbers, to facilitate your recollection of them.

SOLID SALINE MATTERS IN DIFFERENT WATERS.

Proportion in 10,000 *parts.*	PARTS.
In the water of the Elton Sea, or Lake, in Southern Russia	3,000
" of the Dead Sea	2,600
" of the Elbe	3
" from different wells in Dresden	from 3 to 10
" of the English Channel	380
" of the Mediterranean	410
" of the Frith of Forth	312
" of the Thames	2.5
" of the Colne	3.25
Mineral waters—	
" of Bath	20.53
" Bristol hot-well	8.19
" Isle of Wight	88.21
" Cheltenham (old well)	111.6
" Epsom	37.94
" Harrowgate	145.4
" Vicar's Bridge, Scotland	563.10
" Tunbridge	1.32
" Malvern	1.01

To sum up briefly the discussions of this day's lecture: we find that chemically pure water does not occur in nature; that rain-water contains in solution the constituents of atmospheric air; that spring-water and river-water contain a number of salts in solution; and, moreover, that sea-water differs from spring-water only in containing a far larger amount of saline matters.

LECTURE V.

THE SOIL.

Constituents of the Soil....Its Origin....Disintegration of Rocks by Frost....The action of Carbonic Acid....The action of Oxygen....Origin of the Phosphates.

Before entering upon the proper subject of my present lecture—a subject which will occupy us during this and the two following lectures—I deem it necessary to make a few additional remarks upon a point, touched upon in my introduction, relating to the conditions of vegetation. I stated to you that the soil is not an essential condition of vegetable life—at least, not so universally essential to the life of plants as water and the constituents of the atmosphere. I feel that it is important to recur to this subject briefly, since I am quite aware that many of you may deem such an assertion not merely rather bold, but altogether unfounded and utterly absurd. You would found your suspicion of my opinion upon the fact that potatoes, barley, wheat, pines, &c. imperatively demand soil for their existence and development. You may, therefore, think it inadmissible to speak of the soil a a condition *not essential* to vegetable life. But I shall have little difficulty in convincing you that such an opinion is erroneous. Your inference would, indeed, be perfectly just, could you prove that potatoes, barley, pines, and thirty thousand or more other kinds of vegetables, have exclusively a pretension to be designated "plants," because they are attached to the soil by means of roots—that is, if you could make the possession of roots a necessary qualification for certain organized bodies to receive the designation "plants.'— But there is a class of vegetable bodies, known as plants, quite as extensive in numerical amount, if not in the variety of species, either entirely destitute of roots, or possessing only such roots as are not adapted to the reception of matter from the soil, and consequently cannot draw therefrom any nourishment, even when they are attached to it. No one ever has, or ever will, dream of excluding from the vegetable kingdom the members of this class; and it is, therefore, obvious that we must seek for some other mark, or proper distinction of "*plants*,"

than the possession of roots, since this is not a property of all, but only of certain *kinds* of plants.

This is not, of course, the place to enter upon the attempt accurately to define what is to be included in the term "plants." It is sufficient for my purpose to have demonstrated to you that to include the possession of roots in the definition of plants is erroneous; and, consequently, the conclusion based thereupon—namely, that soil is an essential condition of vegetable life—cannot be sustained. For (and I repeat it once more) if there exist plants possessing no roots whatever, or, at least, no such roots as are capable of drawing matter from the soil, and, therefore, require no soil for their full and perfect development, it is obvious that neither root nor soil can be considered *essential* conditions of *vegetable life in general*, notwithstanding that roots and soil are absolutely necessary to the existence of *certain* plants.

Nor can I admit the correctness of a favorite assertion of some authors, that plants not possessing roots adapted to the reception of nourishment from the soil, and, therefore, not requiring soil for their growth, are to be considered exceptions from the general rule. On the contrary, when we reflect upon the immensely extensive diffusion of aquatic plants, especially of the genus *Algæ*, according to the authentic reports of navigators, we might reasonably ask whether the absence of roots and soil does not form the rule, while the possession of roots capable of receiving matter from the soil, and, therefore, the presence of soil affording the suitable materials, may be regarded as the exception to the general rule.

New and surprising as this view may appear to some of you, it is, nevertheless, true; and there is nothing whatever opposed to it in the anatomy and physiology of plants; and these sciences ought to be especially regarded in determining such questions as whether roots and soil are essential conditions of vegetable life in general, or not.

The examination of the soil adapted to the growth of plants must, nevertheless, engage our especial and careful attention, since all those plants which are the subject of *cultivation* belong to that class which possess roots, and, by means of these roots, withdraw matters from the soil indispensable to their existence—as I shall explain more fully hereafter.

The examination of the *physical* condition of that upper stratum of the earth which subserves the purpose of cultivation—*i. e.* the soil—does not belong to the science of Chemistry; we shall, therefore, pass it by, confining our attention to the *constituents* of the soil, beginning with an investigation into their origin, because I am convinced that it is only by this means that we can obtain a correct notion of the importance of soil to the life of certain plants.

The constituents of a soil universally acknowledged to be fertile may be considered under three heads. They consist, first, of many mineral substances, more or less finely pulverized; secondly, of various saline matters or salts, more or less easily soluble in water, together with some silica in a soluble condition; and, thirdly, of organic substances, and especially of vegetables in a state of decomposition: to these last the term *Humus* has been applied. It will be expedient to group the first two classes of substances together, under the title of *inorganic constituents,* since they derive their origin from the decomposition and disintegration of inorganic bodies—that is, from the mountains and rocks of our earth.

To the processes, converting mountain masses into soil adapted to cultivation, we apply the term *degradation.* This term, then, designates the aggregate of all the phenomena which the action of water, of carbonic acid, and of oxygen, produces upon solid rocky masses, terminating in their destruction. The phenomena produced by these agencies upon rocks and mountains may be considered under two divisions, namely, mechanical and chemical; and, although this distinction is nowhere made in nature, it is necessary that we should have recourse to it, since it is indispensable that you should obtain a very complete and satisfactory insight into the nature of these processes.

And, first, with regard to the mechanical part of these processes, it principally consists in the bursting and cleaving asunder of solid rocky masses by the agency of water. You all know that water, when converted into ice in freezing, expands considerably; and your own observations must have presented you with

sufficient instances to convince you that this expansion ensues with very great force, and that it may produce extraordinary effects. Now, conceive a rock or stone pervaded by a number of the most minute fissures and clefts—and this is of very frequent occurrence in nature;—imagine these fissures and clefts filled with water, and this water by frost converted into ice; and it will be perfectly obvious to you that the result must be to cleave the stone asunder; and, upon the subsequent melting of the ice, the previously-solid rock crumbles into pieces.—Such a process is constantly proceeding in all mountains, and, upon a larger scale, the more naked the rocks, and the more exposed they are, consequently, to the humidity of the atmosphere, and to the alternate freezing and thawing of the water which has penetrated into crevices and pores. In this manner, portions of rock, of every variety of magnitude, are constantly separated from mountains, from the finest grit to the largest blocks, which, rolling down to the foot of the mountains, remain exposed to the same influence of the water, and, being thus mechanically subdivided, furnish the chief materials which the mountain streams conduct into the plains, where, after relaxing their impetuous course, they deposit them as gravel, sand, or mud.

In studying the chemical part of the processes of degradation, we must primarily direct our especial attention to the action which the carbonic acid of the atmosphere exerts upon most of the constituents of mountain masses; since, notwithstanding the slowness and apparent insignificancy of this action, it really produces the most extensive and important effects, inasmuch as it proceeds at all times and in all places. You must, therefore, permit me to enter into a very minute consideration of this process, and to illustrate it by means of experiments, as you will soon understand that, without this operation and the results flowing from it, the development of *no plant whatever*, which requires the soil for its existence, would be possible.

The various masses forming the rocks and mountains of our earth, are divided into two classes, namely, 1st, those termed aqueous rocks, and which owe their origin to the accumulation of solid matter deposited from water, and, 2ndly, igneous rocks, or such as owe their original formation to heat, causing the materials of which they are composed to fuse, and from this state of fusion they have been, by subsequent refrigeration, converted into a solid state, such as we find them.

The different terms employed to designate these principal groups of mountain masses, or their subdivisions, belong to Geology, and are quite immaterial to our present purpose. But we must bear in mind that those rocks, which have been formed by the accumulation of solid matter deposited by water, could not have been so formed unless the water had previously contained the materials of which they are composed; and water could not have contained these materials had not the mountains, originally formed by heat, been partially destroyed or disintegrated, and this disintegration or degradation must have had a *cause*, and this cause, namely, the action of the constituents of the atmosphere upon the original igneous rocks, we have now to consider. Geology proves distinctly and incontrovertibly that in the primeval ages of the world, the processes of which I am speaking took place. The degradation of mountain masses went on then, as it does at present, with this difference only, that it proceeded far more rapidly; and the immediate cause of the rapid degradation of rocks in the primeval world was the presence of certain acids in the atmosphere, in such proportions as are no longer existent in our present atmosphere.

Now, whatever may be thought of this matter, or whatever inferences may be deduced from it, the fact is indisputable, that aqueous rocks have originated from the degradation of igneous rocks; and we are ignorant of any power capable of effecting this degradation except those of which I have spoken, and especially that of the chemical action of the constituents of the atmosphere. Before, however, we enter upon the examination and illustration of this chemical process, it is indispensable that we should investigate, at least generally, the properties of the materials forming the masses of the rocks themselves.

You cannot be ignorant of the fact, that the rocks forming what are called primary mountains, are almost without exception made up of several and various constituents; so that, on examining a portion struck off from any mass, we can immediately, and with the unassisted eye, perceive this diversity in its materials;

and it becomes the more manifest the more carefully, by means of various contrivances, we examine the mass. Thus we find minerals exhibiting the greatest differences in color, taste, lustre, hardness, form of crystallization, specific gravity, and (what will not surprise you) in their chemical composition, coëxisting together in the same stone. Different names have been given, accordingly, to different rocks or stones. Thus, for instance, a mechanical mixture of quartz, felspar, and mica, three very different minerals, is denominated *granite;* a combination of felspar and hornblende is called *syenite,* &c. If, on the other hand, we seek for some common chemical property to characterise these minerals, we find that the greater number of them possess a very prominent mark of this kind —namely, that of being chemical combinations of various bases with silicic acid. These compounds are salts of silicic acid, and are designated "*silicates;*" and these silicates are decomposed by the action of the carbonic acid of the atmosphere.

In order to enable you perfectly to understand this very simple chemical process, I must first call your attention to the fact, that carbonic acid possesses an exceedingly powerful tendency to combine chemically with those bases, which, in their free and uncombined state, are soluble in water, and when dissolved manifest that peculiar taste denominated alkaline. These bases are called *alkalies* and *alkaline earths.* And, further, I must observe that carbonic acid obeys this tendency, and combines with these bases, forming *carbonates,* even when they exist already combined with *silicic acid,* in the form of *silicates.* The silicic acid is of course liberated in this operation, and it depends upon circumstances whether it remains on the spot, or is carried off by the water present and deposited somewhere else. Silicic acid may dissolve in the water at the moment of its liberation from the silicates. Silicates may also be produced by artifical means, and some of them, but these are rare exceptions, are perfectly soluble in water.

The following experiment will best prove and illustrate the property possessed by carbonic acid of decomposing the silicates. I take a solution of one of the soluble artificial silicates in water—it is silicate of potass, known as "soluble glass." Immediately upon transmitting carbonic acid through this solution, you perceive a great change takes place. From being perfectly pellucid, it becomes turbid; the turbidity increases more and more, until the fluid acquires a gelatinous consistence, and the progress of the carbonic acid is impeded by its viscidity, until at length it becomes a solid gelatinous mass, so that I can invert the glass containing it, without spilling its contents. This is a chemical process, differing from the decomposition of a silicate, the constituent of a mountainous mass as it occurs in nature, only by the comparative rapidity of the operation. In both cases the nature of the change is the same: the carbonic acid combines with the base, forming a carbonate, whilst the silicic acid is liberated. In the example before us, it is a carbonate of potass that is formed, a substance very readily soluble in water; and the separated silicic acid, combined with water, forms a gelatinous mass surrounding the newly-formed carbonate of potass. In this state of combination with water, the silicic acid is a hydrate, and is still soluble in a large proportion of water; but it gradually separates from this water, and it is then no longer soluble, and at last it will be actually converted into *stone.* Silicious stones formed in this manner artificially, cannot be distinguished from those formed naturally—that is, as minerals: and it is highly interesting to you to know, that such minerals are natural productions of the rapid decomposition of silicates, by the energetic action upon them of carbonic acid.

After these preliminary remarks, let us consider the natural silicates which form the predominant constituents of primitive mountain masses; and of these I must first remark, that most of these silicates are not, like silicate of potass, compounds of the acid with *one* base—on the contrary, their composition is far more complex. Such, for example, as the following: a definite amount of silicate of potass combined with a definite amount of silicate of alumina produce a substance denominated a double salt, because it is formed by the chemical combination of two salts.

You may perhaps, find some difficulty in apprehending distinctly what you are to understand by the term "salt," since it is so different from your preconceived notions. But you must not forget, that chemists understand by the term salt,

chemical combinations of an acid and a base. The term is not limited to bodies possessing a saline taste. A great number of salts, including all those which are insoluble in water, have not a *saline* taste. In like manner, many acids have not a *sour* taste, precisely because they are insoluble in water, and consequently in the saliva. Further, I would wish you to remember that all salts are not composed of *one acid* and *one base*, but that such simple salts may combine with each other, forming more complex bodies, called "double salts." Alum is a well known example of a double salt: it is a combination of two sulphates, namely, sulphate of alumina and sulphate of potass. It is the same with the silicates; they also may combine with each other, forming double salts, and even more complex compounds. Now, it is of such complex substances that the minerals in question consist, constituting the materials making up mountain masses. It is essential that you should bear this in mind, in order fully to understand the process of degradation. Carbonic acid decomposes only those silicates with the bases of which it will combine and form carbonates; whilst it leaves untouched the silicates, with the bases of which it is incapable of combining. The former, therefore, only can be disintegrated by the action of carbonic acid. Now, those silicates which occur as constant constituents of all mountain masses, are exclusively combinations of silicic acid with alumina, peroxide of iron, potass, soda, lime, magnesia, protoxide of iron, and protoxide of manganese. With the exception of alumina and peroxide of iron, all these bases are capable of combining with carbonic acid. All the minerals we are speaking of are double salts, and every one of them contains at least one silicate, the base of which has a tendency to combine with carbonic acid.

These considerations will enable you to form an adequate notion, not only of the extent, but also of the necessity, of the process of decomposition, induced by carbonic acid. by this process the most solid rock is disintegrated, and a material furnished which either remaining upon the spot where it is formed, or being transported and deposited by water, forms the basis of all arable soil, as well as of the aqueous or stratified rocks. A few illustrations will render this more intelligible to you.

The species of stone which is most extensively diffused over the surface of the earth is granite. This, as I have already had occasion to tell you, consists of three different minerals, intermixed. *Quartz* is not a *silicate*, but pure silicic acid; carbonic acid cannot, therefore, act upon quartz so as to cause its disintegration. *Mica* consists of silicate of alumina, persilicate of iron, and silicate of potass. Carbonic acid being capable of combining with the potass, decomposes the latter salt, forming with its potass *carbonate of potass*, and liberating silicic acid. This decomposition of one of its constituents is, of course, attended with the disintegration of the *mica*. Lastly, felspar is a double salt, composed of silicate of alumina and silicate of potass. This ingredient of the granite is far more readily disintegrated than mica; it separates into silicate of alumina, persilicic acid, and carbonate of potass. The two latter substances dissolve, and are carried away by water, whilst the silicate of alumina remains undissolved, and, according to its degree of purity, receives the name of common *clay*, or porcelain clay.

It must be obvious to you that in this process, where two of the constituents of the granite are decomposed, and disintegrated, the whole mass of the granite must, in like manner, suffer degradation. I am sorry that I cannot accompany you to the summit of the Brocken in the Hartz mountains, because you might there obtain the clearest insight into the process I have described. There you would see thousands of blocks of granite lying on the declivities of the mountain, the exceedingly white surface of which contrasts very strangely with the black soil upon which they rest. Upon closer examination, the white surface of the blocks is found to consist of fine clay produced by the decomposition of the felspar, intermixed with grains of quartz of a light grey color, and small shining black scales of mica, the two remaining constituents of the granite. By splitting one of these blocks, the best possible opportunity is obtained of observing the action of the decomposing agencies; an uninterrupted series of transition may be clearly traced from the white clay, forming the outer surface to the light flesh-colored lustrous aspect of the felspar in crystalline scales, not yet reached by the decomposing agent which has destroyed the integrity of the surface. The

solidity and fineness of the granite increasing from the exterior towards the interior, stands necessarily connected with the influence of the same agent. For whilst fragments of the outer surface crumble between our fingers into a coarse powder, we can make no impression upon the interior of the block, where the hardness and solidity of the granite are wholly unimpaired.

In the process of decomposition and disintegration of granite rocks, not only the soluble parts, but the lighter insoluble particles are frequently washed away by water, leaving the quartz behind, as a loose mass, sometimes retaining the original form of the granite block, until frost or some mechanical force destroys even this, converting the whole into a coarse sand, in which, by careful examination, we may find scales of mica and small portions of felspar which have escaped decomposition.

The degradation of rocks composed of syenite proceeds in a similar manner. Syenite, as I have already mentioned, consists of two minerals, felspar and hornblende. The latter is a compound of several silicates, but the bases of all of them are capable of combining with carbonic acid, and, therefore, whilst the felspar is disintegrated in such a manner as to leave the silicates of alumina in the form of clay, all the silicates composing the hornblende are decomposed, their bases combine with carbonic acid, and their whole amount of silicic acid is liberated.

To repeat again, Gentlemen, in a few words, the substance of what I have described to be the process of the decomposition and disintegration of rocks,—it is the water penetrating into these fissures and pores, and subsequently, alternately, freezing and thawing, which mechanically destroys the cohesion of rocks,—the carbonic acid acts chemically upon their constituents, and the combined action and effects of both these agents accomplish the entire process of degradation.

I must, however, call your attention to the fact, that it is not the carbonic acid of the atmosphere exclusively which decomposes the silicates,—the carbonic acid dissolved in the water of springs, and percolating through the mountains, produces the same effect. The influence of spring water in decomposing rocks, does not claim our attention, because it is not of any great importance in the production of soil, but it affords a better insight into the process, than can be obtained by merely observing the changes in rocky masses on the surface of the earth. In the latter case, these products of the decomposition, which are soluble in water containing carbonic acid, especially the carbonates of the bases, are carried off by the water, and nothing is left behind but the insoluble clay silicates, and anhydrous silicic acid. These latter substances remain upon the spot where they are found, whilst the carbonates have disappeared, the water of the atmosphere falling as dew, rain, or snow, having ample opportunity to carry them off during the slow process of disintegration. But such carbonates are found in considerable proportions in springs containing carbonic acid, whether the water of such springs be hot or cold. Here the reverse of what happens with respect to degradation upon the surface takes place, that is, the soluble products of subterraneous decomposition are brought to light, whilst the insoluble, the clay, and most of the silicic acid, remain in the interior of the mountains, just where decomposition of the silicates occurs.

The late Mr. Struve of Dresden, a celebrated manufacturer of artificial mineral waters, proved by his experiments, that water charged with carbonic acid, and brought into contact with various minerals and rocks, dissolves certain portions of them, and forms mineral waters; that is, solutions of salts, precisely similar to those dissolved by the water of springs in the process of decomposition of rocky masses in nature. So that it is immaterial whether water so charged be brought into contact with rocks susceptible of its action, in the interior of a mountain, or in the laboratory. By means of an apparatus invented by Mr. Struve, we can exactly imitate the natural process I have described to you: we can decompose and disintegrate portions of rock, and exhibit the several products of their decomposition, so as to leave no doubt as to the accuracy of our views respecting the means employed by nature for the same purpose.

I must, however, remark that dry carbonic acid has no power to decompose minerals composed of the silicates, therefore granite, syenite, &c., exposed to a

dry atmosphere do not undergo disintegration; the presence of moisture, that is, of water, with the carbonic acid, is essentially necessary to the process.*

Finally, I must now direct your attention to the action of the oxygen of the atmosphere upon certain of the constituents of rocks and minerals, since the results of this action exercise a very important influence upon the life of plants, as you will hereafter have occasion to learn.

An inquiry into the action of oxygen upon mineral masses involves the investigation of the source and formation of two classes of salts, and a certain compound of iron, invariably found in all arable soil, namely, the sulphates and the phosphates, together with the peroxide of iron; but these salts and this iron compound do not always exist in the minerals in the form under which they are found in the soil, previous to their disintegration. The peroxide of iron, that is, you must understand, a combination of metallic iron and oxygen, will afford us the best and most intelligible illustration of this subject. A chemical compound of iron and oxygen, containing a smaller proportion of oxygen than the peroxide, is so frequently met with in the mineral masses forming rocks and mountains, that it may, perhaps, be asserted that not a single mineral exists which does not contain more or less of this compound of iron and oxygen. Now this substance, when water is present, possesses the property of gradually absorbing as much oxygen from the atmosphere as to become converted into peroxide of iron, and as this transmutation is always accompanied by an increase of volume, it must necessarily cause a loosening of the texture of the mineral, in which it occurs, and finally make it crumble to pieces. A never-failing sign of this chemical process going on in a mineral, is the appearance of a reddish rusty color on its surface, this is the color of the peroxide of iron. You will, perhaps, remember, Gentlemen, that change of color which takes place, when upon ploughing up a dark subsoil,—a very common agricultural operation,—the dark earth, on exposure to the air, assumes a reddish hue; this is owing solely to the peroxidation of iron. The origin of the salts called sulphates, which, like peroxide of iron, are always present in the soil, although very rarely, indeed, found as constituents of the rocky masses which have not undergone the process of disintegration and decomposition, is precisely analogous. The solution of the question, how it should happen that sulphates which are not present in the minerals, from whence the soil is formed, should, nevertheless, be always found in the soil, is not very difficult to answer. We have only to consider the process of oxidation to which an universally diffused mineral substance, namely, sulphuret of iron, (iron pyrites) is liable, and it will immediately be understood. Sulphuret of iron has been found to be present in every species of mountain mass, although only in a state of admixture, and, therefore, as an unessential constiuent. It is a compound of sulphur with metallic iron, possessing metallic gravity and lustre, looking, indeed, much like brass, and is insoluble in water. Sulphuret of iron possesses the property of attracting and gradually absorbing oxygen, giving rise to the conversion of the sulphur into sulphuric acid, and the iron into an oxide or a base, which combines with the newly-formed sulphuric acid, forming sulphate of iron (known as copperas, or green vitriol). The salt thus produced must, doubtless, be considered to be the cause of the presence of all the other sulphates found in the soil.

Chemical experiments show us, that sulphate of iron cannot come into contact with carbonate of lime, or any of the alkaline carbonates, without undergoing decomposition. With carbonate of lime it forms sulphate of lime (gypsum), and peroxide of iron, the carbonic acid escaping. You must not, therefore, be surprised when, upon examining a soil, you find no sulphate of iron, and yet invariably you find other sulphates, because bases which have the power of decomposing sulphate of iron are always present in the soil.

Finally, with respect to the presence of the phosphates in the soil, the oxygen of the atmosphere has nothing to do with their formation, the phosphates already existing in rocks and minerals do not admit of a higher degree of oxidation. The process of disintegration merely liberates these salts mechanically. All the phosphates, moreover, which occur as constituents of minerals, are insoluble in water, and, therefore, are not acted upon by carbonic acid nor by oxygen.

* The polished surface of the Egyptian sculptures, which have resisted the atmospheric influence for thousands of years, affords a striking illustration of this remark.

But, Gentlemen, I am well aware of the objections which have been, and are still, made to this view of the origin of the phosphates found in arable soil; I will now state some of these objections, and, I trust, convince you of their fallacy.

In the first place it is said, that phosphates occur too rarely as constituents of minerals, to account for their presence in the soil; secondly, that these phosphates—or at least the phosphoric acid—is derived from animal manures, and especially from bones; and lastly, since the phosphate of lime which is found in the eggs of fowls seems to be formed from substances which apparently contain no phosphoric acid, it has been supposed to be generated out of nothing, or to have been created by the transformation of some other element; and you may, unless you attend to my cautions, be led to suppose that by some such mysterious process it may be formed in the organism of plants, or in certain soils. Well, we may admit that the phosphates are of a rare occurrence as minerals. Quartz, mica, felspar,—&c. are incalculably more abundant than apatite, wagnerite, and other native phosphates. But if you bear in mind that the amount of phosphates in arable soil is very small, you will see there is no necessity that they should occur in any large proportion in rocks, in order to furnish the supply. We have only to be assured that phosphates do really occur as constituents of rocky masses, without troubling ourselves about the amount. A great many localities are known where phosphates are present in granite, gneiss, mica slate clay slate, &c. and in these cases, it is important to remark, the phosphates were discovered only by accident. Mineralogists in examining the physical characters of these rocky masses, having met with portions more or less crystalline, which evidently differed from the usual constituents of the rocks, were led to make a more particular—that is to say—a *chemical* examination of these portions, and this, quite unexpectedly, showed them to consist of phosphates. Direct investigations, so far as I know, have never been made with the view to determine the question whether the phosphates are always found in these rocks, nor is it probable that experiments will be undertaken upon a sufficiently large scale for this purpose, for some time to come, since the detection of minute proportions of phosphates is frequently a difficult task, even when we are certain of their presence. The phosphoric acid very readily escapes detection. It is unnecessary for me to explain the causes of these difficulties in analysis, it is sufficient for you to know that they exist. Phosphates, however, have been detected in all primitive mountains whenever they have occurred in large quantities or in a crystalline form, but it is very easy to overlook them when in smaller proportions and in a non-crystallized state. The rarity of their occurrence in a crystalline form is no proof of their rarity in an amorphous state. There seems, therefore, to be no good ground to doubt that the phospates found in the soil have been originally constituents of mountain masses, and that their presence in the soil is owing to the degradation of those masses.

With respect to the opinion that the phosphates of the soil owe their origin to manure and especially to bones, I may first inquire whence do you suppose the phosphoric acid of manure, or rather of animal bodies, to come? In answer to this, some may say that it is derived from the aliments of which animals partake; others may suppose it is actually created in the animal body. If the phosphoric acid of the animal body be derived from the aliments, how does it become a constituent of those aliments? You see we must go back to that contained in plants, or rather in the soil, and this is merely proceeding in a circle. What really happens is this: carniverous animals (the lion for example) derive phosphoric acid from the bones and flesh of other animals of the herbivorous class which they devour, these, from plants upon which they feed, and plants draw it from the soil; and the presence of phosphoric acid in the soil is owing to the disintegration of rocks. Thus, you perceive, that phosphoric acid, as well as sulphuric acid—essential constituents of organized beings—are derived originally from the mineral kingdom. The fact that in bone manure you bring phosphoric acid into your fields, does not at all invalidate this conclusion, since all the phosphoric acid of bones once belonged to vegetables, and was by them derived from the soil, and came into the soil by its separation from mineral masses. If, however, it were granted that the phosphoric acid of the animal kingdom could have had some other origin, this would not explain the circumstance that

plants which have never received manure, *ex gr.* those growing wild upon soil never cultivated, contain phosphoric acid: this must be referred ultimately to the disintegration of rocks.

Finally, if any of you, gentlemen, should have embraced the notion that phosphoric acid could be formed by the transmutation of some other substance, let me assure you that such an assumption is altogether unwarranted. No experiments of any value, no observations worthy of the least confidence, justify the opinion of such a "creation" of matter. Every theory of this kind rests only on illusion and error, and justly excites the ridicule and scorn of every well-informed chemist; and who but chemists can you admit to be competent judges in questions of this kind?

LECTURE VI.

THE SOIL.—(CONTINUED.)

Recapitulation....Humus—Its Formation, and Nature....Process of Decay or Putrefaction.

GENTLEMEN:—Before we enter upon the consideration of new subjects, permit me briefly to recapitulate the substance of my last lecture, since this will both serve to impress the most important points more deeply upon your mind, and enable you the better to follow the thread of our discourse.

In the first place, then, I told you that the constituents of the soil may be divided into two classes; namely, into such as owe their origin to the degradation of rocks and minerals, and such as arise from the decomposition of organic substances, more especially of vegetable matters.

In inquiring into the origin of the mineral constituents of the soil, we had to study the process by which rocks and mountain masses are converted into soil suited to cultivation, which process we termed degradation; and I stated that the mechanical part of the process, the *disintegration*, is performed chiefly by water alternately freezing and thawing upon and within the substance of rocks, and that the chemical part of the process, the *decomposition*, consists in the action of carbonic acid upon the silicates, and in a small degree in the action of oxygen upon certain minerals by which they are oxydized. I then, in conclusion, explained to you the source of the phosphates found in the soil.

If you have bestowed upon the discussion any attention, you cannot fail to be acquainted with the mode of formation of all the various mineral constituents of the soil; you know the origin of sand, of clay, lime, the carbonates, sulphates, phosphates, and silicic acid; and we may, therefore, now enter upon the consideration of the last constituent of the soil of which we have to treat, namely, the HUMUS.

Humus, as contained in the soil, is not always exactly and identically the same in appearance or chemical constitution. The following properties, however, may be considered characteristic of all kinds of humus found in soils, with a few exceptions.

Humus is a dark brown or black substance of a loose texture, easily reduced to powder between the fingers when dry, but it possesses an extraordinary power of attracting moisture from the atmosphere, and of absorbing gaseous substances; it will imbibe water to the extent of three-fourths of its own weight without becoming moist. The structure of the vegetable substances which have by decomposition given rise to the formation of the humus, may frequently be traced in it. Humus is almost entirely insoluble in cold water, and is very sparingly soluble in boiling water, which forms with it a gold-colored solution by dissolving a very minute proportion, and this solution becomes turbid on exposure to the atmosphere, depositing a slight sediment of a dark brown color.

Humus which has once been completely deprived of water by drying, or which has been exposed to frost, loses even this slight degree of solubility.

By treating it with strong bases, the alkalies, soda or potass, for instance, it is

converted into a substance possessing the properties of an acid, which has been called humic acid; this, combining with the alkaline bases, forms salts, denominated *humates*. These salts dissolve freely in water, forming dark brown solutions.

They are decomposed by the addition of strong acids, such as hydrochloric acid for instance, giving rise in this case to the formation of hydrochlorates, and to the separation of humic acid. This substance is almost entirely insoluble in cold water. That part of the humus which is not acted on by the alkalies is altogether insoluble, to this the name *humine* or humus coal has been applied.

Finally, humus, as the process of decay proceeds in it, disappears altogether, being slowly combined with the oxygen of the atmosphere and resolved into carbonic acid, leaving behind only a very small proportion of various salts, which upon examination will be found to be those, we may detect in the plant, to the decomposition of which the humus owed its origin.

If you select a lump of vegetable mould produced by the decay of dung, or of a good garden soil, you will perceive, even with the naked eye, but much better with a magnifying glass or microscope, that it still retains the structure of vegetable fibre. If a portion of this earth be dried as completely as possible, and placed upon one scale of a balance, whilst on the other are placed weights sufficient to restore the equilibrium, you will find, in a few seconds, that, in order to maintain the equilibrium of the balance, you must add additional weights. This must convince you of the very powerful tendency which exists in humus to attract moisture from the atmosphere, since that is the reason of its increase in weight.

A few experiments will serve to illustrate, and to impress upon your minds what I have said with respect to the properties of humus.

A portion of vegetable mould, or earth rich in humus, allowed to stand for 24 hours covered with water, at its usual temperature, say about 66°, and filtered, will be found to impart only a very feeble yellow color to the water. This proves that humus is nearly insoluble in water at common temperatures.

If we heat a portion of the same vegetable mould for some time with boiling water, and filter, we obtain a gold yellow fluid, showing that solution, to a certain extent, has taken place; but this amounts to no more than about one-half per cent., so that humus is very scantily soluble even in boiling water.

By adding to this solution hydrochloric acid, the humus is separated from the fluid, and falls to the bottom of the vessel in slight brown flakes.

When this kind of earth is heated with carbonate of potass and water, a brown-colored solution is obtained, which is a solution of humate of potass: this has been formed at the expense of part of the carbonate of potass employed. A portion of this has part with its carbonic acid, which has been transferred to the remaining portion, giving rise to the formation of a bicarbonate of potass (that is, a salt with double the amount of acid contained in the carbonate.) The liberated portion of potass has combined with a part of the humus, and formed a humate of potass; this is copiously soluble in water—hence the dark color of the solution.

If a portion of this fluid is decanted, and hydrochloric acid added to it, the humate is decomposed; the hydrochloric acid being the stronger acid, hydrochlorate of potass is formed, and humic acid separates, which being nearly insoluble in cold water, subsides to the bottom in light brown-colored flakes. The supernatant fluid retains only a scarcely perceptible yellowish tint. So that, even with the presence of hydrochloric acid, humic acid is extremely little soluble.

When, instead of carbonate of potass, we treat humus or vegetable mould with a strong solution of caustic potass, and allow it to stand a few hours, we obtain a dark brown, almost black fluid; humate of potass being formed and dissolved to a large amount.

Treating the dark-colored fluid obtained with hydrochloric acid, hydrochlorate of potass is formed, the insoluble humic acid subsides to the bottom of the vessel, and the supernatant fluid has the same faint yellowish color, as that treated with carbonate of potass and hydrochloric acid.

When humus is intimately mixed with a soft paste made of carbonate of lime (chalk), and water of the common temperature added, and the mixture allowed to stand for some hours, and then filtered, a colored fluid is obtained, in which we may detect dissolved humic acid. But if a paste of slaked lime is substituted

for the chalk, and treated with humus in the same manner, the fluid obtained is very nearly colorless, affording scarcely a trace of dissolved humus or humic acid. This is an important fact to which we shall have occasion to revert hereafter.

If we treat a mixture of carbonate of lime and vegetable mould with boiling water, and filter it, we obtain a golden yellow-colored fluid, indicating a solution of a certain amount of humus; but the quantity dissolved is not greater than if we had treated the humus with boiling water without the chalk. In this case also the humic acid is separated from the solution by hydrochloric acid.

Finally, by proceeding in the same manner with slaked lime, and even boiling the mixture in water, after filtration the fluid will be found to have acquired only a very slight yellowish tint; and, upon adding hydrochloric acid to it, no humic acid will be separated.

Although this is not the place for us to enter upon the discussion of the conclusions which may be deduced from these facts, as we shall have occasion to do so in the sequel, I cannot refrain from pointing out to you the errors into which many writers on agriculture have fallen upon this point.

Most of these writers, when treating of the uses of lime and carbonate of lime (chalk) in agriculture, have asserted that their efficacy is owing chiefly to their combining with the insoluble, or at least very difficultly soluble, humus of the soil, forming a humate of lime, which, dissolved in water, is drawn up by the roots of plants for their nourishment. But these experiments which I have described to you, and which you may very advantageously make for your own satisfaction, indubitably prove the unsoundness of such a conclusion. I have repeated them with great care, together with many others, in order to examine into the opinions of certain writers on the chemistry of agriculture, respecting the supposed formation of a soluble humate of lime, in the soil—but invariably with the same results. It is, however, alleged that there are two humates of lime, a basic and a neutral humate, and the latter is said to be soluble in 2000 parts of cold water. This so-called neutral humate of lime, of which these writers are so anxious to prove the existence and to believe it subservient to vegetation, is prepared by mixing a solution of humate of potass, such as I have before described, with hydrochlorate of lime in excess; a precipitate is obtained, which they have supposed to be the neutral humate of lime. But the substance thus obtained, whatever it be, is only soluble in 10,000 parts of water. Upon a careful investigation, however, of this substance, it has turned out to be a double salt, namely, humate of lime and hydrochlorate of lime, which, in this state, is soluble in water to a very slight degree, giving no warrant whatever for the assertions which make it a neutral and soluble humate.

After having thus explained to you the properties of humus, we will now direct our attention to the source or origin of this substance, as a constituent of the soil. This investigation is the more necessary, because the real use of humus in promoting vegetation will become perfectly clear to you when you are acquainted with its origin and formation.

It is universally known that plants and animals, and all the various parts of which they are composed, are subject, after death, to certain processes of decomposition, causing a more or less complete change in their organic structure, and, under favorable circumstances, proceeding to their entire dissolution or destruction. These processes of decomposition are denominated, according to the different phenomena attendant upon each, *decay* and *putrefaction*.

I may, however, remark, that we very seldom have an opportunity to see in nature, either of these processes of decomposition in their pure form; since we almost invariably find phenomena belonging more especially to one of these processes, mixed up with those belonging more appropriately to the other—that is, the characteristic features of decay are mixed up with those of putrefaction, and *vice versâ*. But in order to give you the clearest possible insight into the nature of decay and putrefaction, we will disregard this circumstance, and endeavor to present you with a definite delineation of each in its purest form.

Vegetable fibre, although not always presenting the form in which we observe it in wood, nevertheless forms a constituent part of all plants. Whenever, therefore, a plant decays, or putrefies, its vegetable fibre must decay, or putrefy; and as this forms by far the larger portion of the whole substance of plants, it is evident that if you are once acquainted with the phenomena of decay, or putrefac-

tion, in vegetable fibre, you will understand these processes as occurring in the whole mass of plants, or any parts of them.

Vegetable fibre, according to chemists, consists of Carbon, Hydrogen and Oxygen ; in 100 parts by weight it is composed of—

52.5	Carbon.
42.3	Oxygen.
5.2	Hydrogen.
100	

I must entreat you to remember these numbers, as we shall frequently have occasion to revert to them.

When vegetable fibre is burnt in the open air, or in oxygen gas, that is, in circumstances favorable to a rapid combustion of its carbon and hydrogen with oxygen, carbonic acid and water are formed, and escape in the form of gases, nothing remaining of the vegetable fibre after its complete combustion. It may be safely assumed that in this process the hydrogen burns first, from its greater tendency to combine with the oxygen, the carbon enters into combustion subsequently. If you look carefully at a blazing splinter of wood, you will perceive a manifest difference in the flame, that part of it which is nearest the wood being blue and feebly luminous, whilst that farthest from the wood is more powerfully luminous: it is the hydrogen which burns in the former, the carbon in the latter place. The same difference is still more evident in the flame of a lighted taper; for although the substance in a state of combustion has not the same constitution as the wood, the illustration is equally applicable to our purpose; because here carbon and hydrogen exist in circumstances highly favorable to their combination with oxygen. That part of the flame of a candle which is in immediate contact with the wax is feebly luminous and blue, while the upper part of the flame is white and strongly luminous; the hydrogen burns or is combining with oxygen at the lower part, while the carbon is burning at the upper part. This proves that hydrogen combines with oxygen sooner than carbon.

We have supposed in the before-mentioned case, the vegetable fibre to be placed in circumstances favorable to its combustion, in contact with oxygen sufficiently abundant to burn all its carbon and hydrogen: but what will take place if, all other things being equal, the amount of oxygen present is not sufficient? In this case experience tells us the combustion of the hydrogen will be effected, whilst that part of the carbon, for which there is not sufficient oxygen, appears in the form of soot. Thus it is evident that hydrogen enters into combustion with oxygen before carbon; and where the amount of oxygen present is limited, in preference to it.

The process of decay bears a remarkable resemblance to that of combustion.

Absorption of oxygen from the atmosphere takes place, and carbonic acid and water are formed in decay, exactly in the same way as in combustion, but without the appearance of fire; and I beg to call your particular attention to the fact, that the hydrogen combines with the oxygen in preference to the carbon, in decay as well as in combustion, and this necessarily causes the proportion of carbon in the residue to increase in the decaying substance, notwithstanding that a part of the latter also becomes oxidised, and forms carbonic acid.

To render this intelligible, let us suppose vegetable fibre, in a moist state, exposed to the atmosphere for a considerable time. The oxygen of the atmosphere, in the first instance, will combine with part of the hydrogen of the fibre at its surface, forming water, and, consequently, a corresponding amount of the oxygen and carbon, combined with this hydrogen in the fibre, will be liberated. Now, chemical experience has proved that different substances combine with each other with greater facility at the moment of their liberation from other combinations (technically termed their *nascent state*,) than at any other time. This is precisely the case in decay; the oxygen and carbon are in contact at the instant they are liberated from vegetable fibre, in consequence of its hydrogen forming water with the oxygen, and it is, therefore, in accordance with the general law of chemical combinations, that they should unite, and form carbonic acid; and this under circumstances in which carbon alone does not usually combine with oxygen, as you know, that in order to burn a piece of ordinary charcoal, *i. e.* to make it enter into combination with oxygen, and form carbonic acid, it is necessary to heat it to redness.

Further—carbon and oxygen combine, and form carbonic acid, only in definite proportions, namely, 27.65 parts by weight of carbon, and 72.35 parts by weight of oxygen. Now, vegetable fibre contains so much carbon, that even if all the oxygen present combined with carbon, and formed carbonic acid, it would not consume it all, and, therefore, when all this oxygen is expended, carbon necessarily remains. Let us take the extreme case, that 100 parts of vegetable fibre undergo completely the process of decay; the result must be, that after 5.2 parts of hydrogen have combined with atmospheric oxygen forming water, the 42.3 parts of oxygen of the fibre will combine with 16.1 of the 52.5 parts of carbon present forming carbonic acid, and thus leave 36.4 parts of carbon uncombined.

We do not, however, know any instance where the process of decay has proceeded so far as to leave nothing but pure carbon. On the contrary, we know that in all processes of decay, a period arrives when the carbon of the vegetable fibre begins to combine with the atmospheric oxygen, and after the lapse of a considerable time, it is all formed into carbonic acid, and nothing whatever remains of the vegetable fibre.

The decaying substance grows richer and richer, in its proportionate amount of carbon, from the separation of hydrogen, whilst the carbonic acid formed at the same time is the result of the combination of the carbon and oxygen of the vegetable fibre, and before the oxygen of the atmosphere begins to take a part in the formation of the carbonic acid. Thus whilst vegetable fibre contains 52.5 per cent. of carbon, it has been found, after having undergone partial decay, to contain 54 per cent.; and at a still more advanced period of decay 56 per cent.; the physical appearance of the decaying substance becomes, of course, changed with these alterations of its chemical constitution. It assumes first a brown tint, which gradually deepens, until it becomes nearly, or quite, black; this appearance points out to a certain extent the nature of the chemical change it is undergoing; it indicates an increasing proportionate amount of carbon in the mass, owing to the separation of hydrogen.

To recapitulate, we apply the term *decay* to that process of decomposition of organic substances, in which, with absorption of atmospheric oxygen, the separated elements of the decaying substance combine into new forms: namely, into water and carbonic acid.

I wish you particularly to understand, and to remember, that the formation of water is owing exclusively to the combination of the hydrogen of the decaying substance with the oxygen of the atmosphere; whilst the formation of carbonic acid takes place principally at the expense of the oxygen of the decaying substance; and that a residue rich in carbon must necessarily remain in all cases where the oxygen present is not sufficient to oxidize the entire amount of the carbon, forming it into carbonic acid. In referring to combustion, I wished to convey to you a clear notion of the fact that the combination of the hydrogen of the decaying substance with oxygen always precedes that of the carbon.

I mentioned another process of decomposition of organic substances, designated *putrefaction*; a knowledge of this process being of great importance to you, I shall enter into a consideration of it in some detail; and it will very materially assist you in understanding putrefaction if I premise a few remarks upon carbonization, *i. e.*, for example, the process of burning wood into charcoal. We will still confine our attention to vegetable fibre.

The process of charring, or carbonization, is the decomposition of an organic substance by artificial heat, atmospheric oxygen being excluded. It is evident that the products of this decomposition must be different to those obtained by combustion. For, whilst in the combustion of woody fibre the formation of water takes place copiously, owing to the free access of the atmosphere, and to its oxygen combining with the hydrogen of the woody fibre, in carbonization the amount of water formed is very insignificant. In the latter process, the oxygen and hydrogen of the organic substance may be supposed to divide between themselves the carbon to which they were previously united in common, forming compounds of hydrogen with carbon, and of oxygen with carbon; but since these compounds do not require the whole of the carbon present, a portion of it remains behind uncombined. It is, indeed, most frequently for the sake of this residue that the processes of carbonization employed in the arts are had recourse to, as, for instance, in charcoal burning. For, let us even assume that the whole

amount of the hydrogen of the vegetable fibre, 5·2 parts, combines with the largest possible amount of carbon, namely, 32 parts; and that the 42·3 parts of oxygen also combine with the greatest possible proportion of carbon, that is, 16 parts; this will make 48 parts of carbon to be consumed in the formation of the new compounds, which, being volatile, escape and leave somewhat more than 4 per cent. of carbon behind as a residue. Of course, it is perfectly obvious, that in the process of charcoal-burning, which I have quoted as an example and illustration, there must remain far more than 4 per cent. of the wood, in the form of charcoal. Let me, however, remind you that, in order to render the explanation of the process perfectly intelligible, I have excluded from this calculation the formation of water, which invariably takes place in the process of charring vegetable fibre or wood, consuming, of course, part both of the oxygen and hydrogen of the substance, and thus preventing them from combining with, and carrying away carbon. Moreover, I assumed that the hydrogen should combine with the greatest possible proportion of carbon, namely, 32 parts, which does not really occur in making charcoal, but it unites with carbon in a far smaller proportion. My calculation was intended to prove, that if the largest possible proportion of carbon were consumed, some would still remain uncombined; and you will, therefore, perceive that, in the carbonization of wood or vegetable fibre, there must of necessity be a residue of carbon.

Carbonization, then, is characterised and distinguished from ordinary combustion by its products differing from those of combustion, in consequence of the exclusion of the atmospheric oxygen. Nevertheless, it has much in common with combustion, where the latter process goes on with the presence of only an insufficient amount of oxygen, especially in leaving a carbonaceous residue, which in carbonization is called charcoal, and in combustion, soot.

Now let us imagine vegetable fibre undergoing spontaneously the slow process of decomposition under circumstances which exclude completely the oxygen of the atmosphere, and it must be evident that the phenomena occurring will be essentially the same as in carbonization. Compounds of hydrogen and carbon will be formed principally, together with small quantities of water and carbonic acid, and a carbonaceous substance will remain, approaching more or less to pure carbon, just as is the case in carbonization. I need only remind you of what takes place in marshes, and in pools of stagnant water, at the bottom of which a number of vegetable matters, consisting chiefly of vegetable fibre, putrefy under cover of water, which completely precludes the access of atmospheric oxygen. Bubbles of air are seen constantly ascending from the bottom of these marshes or pools; these bubbles will, upon examination, be found to consist of carbonic acid, or carburetted hydrogen gas, which are the gaseous products of the decomposition of plants by the process of putrefaction. And if you examine the mud of pools and marshes you invariably meet with a black carbonaceous substance; this is, the other product of decomposition corresponding to the charcoal, remaining after the completion of the process in charcoal burning.

Now, both these processes which I have endeavored to make intelligible to you, namely, decay and putrefaction, concur in the formation of *humus*, this being the carbonaceous residue of the decomposition of organic matter. But there is no doubt that *decay* bears an infinitely larger share in the production of humus than *putrefaction;* and I trust you now understand enough of both these processes, to have no doubt as to the origin and source of humus.

I cannot, however, quit the subject before us without offering you a few additional remarks, which may serve to elucidate several points which will prove of importance to you when we shall come to speak of the influence of humus upon vegetable life,—its action in promoting vegetation.

In the first place you will bear in mind that in all I have hitherto said respecting the processes of decay and putrefaction, I have confined myself to pure vegetable fibre, a substance having only carbon, hydrogen, and oxygen, as its essential constituents, since vegetable fibre forms the principal part of all plants, and since all the essential phenomena of the decomposition of pure fibre are exactly analogous to those of the decomposition of wood, and of the leaves and roots of plants.

Plants, however, are made up of other matters besides vegetable fibre, and there is one of these invariably found which, in addition to carbon, oxygen, and

hydrogen, contain *Nitrogen* as an essential constituent. This is vegetable *albumen.* The decomposition of this nitrogenised substance gives rise to the formation of another substance, namely, Ammonia, a compound, as you know, of nitrogen and hydrogen, with which you have already become acquainted, when we were treating of the constituents of atmospheric air. This gaseous and very soluble substance is, therefore, invariably found in the humus of the soil, and its amount is the greater, the larger the proportion of nitrogenised substances which, by their decomposition and decay, have contributed to the formation of the humus. And I may here mention, incidentally, that all animal substances are richer in nitrogenous matters than vegetable substances, and consequently, the humus, in the formation of which, animal matter has borne a part, must necessarily be richer in ammonia than humus formed exclusively by the decomposition of vegetable substances: we shall have occasion to return hereafter to this subject.

Another point which we must not silently pass over relates to the salts contained in humus. Every one of you knows that upon burning wood, or any other vegetable substance, there remains something unconsumed, which we call *ashes*, and which contains all the incombustible and non-volatile ingredients of the vegetable substance burnt.

All plants, without a single exception furnish ashes upon being burnt, but in different proportions, and of various chemical constitution. There are differences in the chemical composition of the ashes of different parts of one and the same plant. As an illustration I will give you the results of some experiments made by De Saussure upon wheat-straw and grain; and I may at the same time remark, that similar differences will invariably be found between the ashes of the seeds and the leaves of all plants.

100 parts of Ashes contain,	Of Wheat Straw.	Of Wheat Grain.
Carbonate of Potass	12·5	15
Phosphate of Potass	5	32
Hydrochlorate of Potass	3	0·16
Sulphate of Potass	2	
Earthy Phosphates	6·2	44·50
Earthy Carbonates	1	
Silica	61·5	0·50
Metallic Oxides (Iron)	1	0·25
Loss	7·8	7·59

As we shall again treat upon this subject when speaking of the inorganic constituents of plants, and the relative proportions in which various salts are present in vegetable substances, we need make no further remark in this place, except to call your attention to the very complex chemical constitution of the ashes remaining after the combustion of plants; this will strike you upon glancing at the above table. Now, if we substitute the process of decay for that of combustion, it must at once be evident to you that these salts or inorganic matters, being incombustible and non-volatile, will remain in the humus. It can, therefore, be no matter of surprise to you to find, upon burning humus, whether it be derived from the decomposition of vegetable or animal substances, that a number of salts invariably remain in the form of ashes. And these are, indeed, precisely the same as would have remained as ashes, had the vegetable or animal substance been directly subjected to combustion, without previous decay.

It is scarcely necessary for me to mention that the processes of decay and putrefaction materially add to the amount of salts in the soil. We may, therefore, consider decay in this respect also as a kind of combustion occurring in the ground, and leaving nothing but ashes behind,—that is, the non-volatile inorganic constituents of the decaying plant. In one word, *Humus* invariably contains the ashes of the organic substances from which it has been formed by the processes of decomposition; and I must beg of you to remember this important fact, as I shall frequently refer to it when treating of manures in a subsequent lecture.

END OF PART I.

PART II.

LECTURE VII.

THE CONSTITUENTS OF PLANTS.

Recapitulation of the preceding, or first division of these Lectures....General Remarks on the Constituents of Plants....Division of them into two classes, Proximate and Remote, or Volatile and Fixed Constituents.

GENTLEMEN:—Before entering upon the second part of the subject of these Lectures, namely, the examination of the nature of the constituents of plants, and the investigation of the sources whence they are derived, I deem it most desirable to review, briefly, all the topics discussed in the preceding Lectures, in order to impress them more indelibly upon your memory.

Assuming, as the foundation of all our inquiries, the unexceptionable and hitherto indisputable facts, that no formation of new matters, which we deem elementary, ever takes place; and that no one element can be transmuted into another, either in the living organisms of plants and animals, or elsewhere, we began in the first instance by inquiring, by what bodies are plants surrounded? with what matter do they come into contact? since this, of couse, is the only natural and direct way of ascertaining whence plants secure their nourishment. And since we know of no other source from which they can derive the necessary materials to build up their structures and to exist upon, than atmospheric air, water, and soil, we naturally directed our attention, in the first place, to an investigation of the properties of these bodies. And again, as air, water, and soil, are themselves exceedingly complex, we found it impossible to consider them in the aggregate, and as they exist in nature; but, on the contrary, were obliged to separate them, and to investigate severally their various constituents.

Thus, whilst treating of the atmosphere, we made ourselves acquainted with the properties of oxygen and nitrogen, the two gases which constitute by far the largest proportion of its whole volume; and, at the same time, as smaller or larger amounts of aqueous vapor, carbonic acid and ammonia, are present everywhere, and may at all times be detected in the atmosphere, we regarded these bodies also as its essential constituents. But these latter gaseous bodies are themselves compounds, Aqueous Vapor consisting of hydrogen and oxygen; Carbonic Acid, of carbon and oxygen; and Ammonia being a compound of nitrogen and hydrogen. We thus found, that out of the numerous elementary bodies (that is, such as cannot be decomposed) known to chemists, only four enter into the composition of the atmosphere, namely, Nitrogen, Oxygen, Hydrogen, and Carbon. But we did not rest satisfied with ascertaining merely what are the substances composing atmospheric air; but we proceeded further, and inquired, whence do these substances originate,—how do they enter into, and become part of the atmosphere?

The solution of this question led us to the consideration of some highly important and deeply interesting phenomena, which afforded us an insight into part of the ways of that Infinite Wisdom which presides over the arrangement of all terrestrial things. The component parts of the atmosphere, studied with a view to discover their origin, enable us to perceive that the existence of the animal kingdom in its present state would not be possible without the simultaneous existence of vegetation upon the surface of our planet; those of the phenomena which belong more especially to our present purpose demonstrated to us that all the constituents of the atmosphere, with the exception of its nitrogen, are in a state of ceaseless circulation, passing through various changes, in a more or less

circuitous rotation, and returning to the atmosphere only to begin this circuit again.

Thus, the the *ammonia* of the atmosphere is transferred to plants in the organism of which it is decomposed, and one of its constituent elements, viz: nitrogen, employed in the formation of their various nitrogenized matters; these enter into the animal body, and having performed most important offices therein, the nitrogen quits it, in combination with other elements, and in the processes of decay and putrefaction reässumes its original form, that is, it combines with hydrogen and forms ammonia, and intermixes again with the atmosphere.

In the same manner aqueous vapor from the atmosphere passes through vegetable and animal bodies, although by a less circuitous route.

The aqueous vapor of the atmosphere is converted into water, and falls in the form of dew, rain, snow, &c. It serves as a solvent for a great number of substances. It passes through vegetable and animal organisms, where, in many ways, and for various purposes, it becomes separated into its elements, hydrogen and oxygen. These elements, however, invariably combine again in the processes of combustion, decay, and putrefaction, forming water; and this water, by evaporation, finally returns to the atmosphere as aqueous vapor, to begin again the same eternal circulation.

The carbonic acid of the atmosphere pursues precisely the same course, its elements pass through vegetable and animal bodies, under the most various forms and combinations, and finally, become again restored to the atmosphere as carbonic acid. You will also remember that I explained to you, in the second and third Lectures, that the atmospheric oxygen passes through similar changes and undergoes analogous variations. And I cannot refrain from reminding you again of the beautiful and highly important law of *the diffusion of gases*, owing to which gaseous substances of the most various gravities completely and perfectly intermix, without the agency of the winds, or any other mechanical causes.

A more especial examination of water was necessary, inasmuch, as the principal amount of this substance is spread over the earth in a fluid state, and as a fluid possesses properties which do not belong to it in the form of aqueous vapors, as it exists in the atmosphere. We found that there are considerable differences between the several kinds of water. Thus, rain-water differs from spring-water, and this again is not like river-water or sea-water. And we further found, that every variety of natural water contains the constituents of the atmosphere, namely, oxygen, nitrogen, carbonic acid, and ammonia, although in different and variable proportions. We saw that with the exception of rain or snow-water, all kinds of water contain solid substances, especially salts, in solution, and that the amount of salts in water is by no means to be disregarded when we are judging of the action of any description of water. Finally, we became acquainted with the most important fact, that everything necessary for the subsistence of a not inconsiderable part of the whole vegetable kingdom, namely, of marine plants, is found to be present in sea-water. I, moreover, deemed a knowledge of this fact of some importance, in the very beginning of our inquiries, because it enlarges our views, and refutes the erroneous definition of the term plant, which makes it signify "bodies deriving their nourishment from the soil by means of roots," since we cannot help admitting that the vegetables inhabiting the ocean are plants, and that very numerous groups of plants exist, which possess no roots capable of absorbing nutritious matter from the soil, and require, therefore, no soil, in the ordinary acceptation of the word.

Finally, the investigations of the soil led us to describe in detail, two chemical processes, degradation and decay, because without some knowledge of these processes, it would be impossible to obtain a clear insight into the origin and mode of formation of the various constituents of the soil.

We divided all the substances found in the soil into two classes, namely—1st, those formed by the decomposition and disintegration of rocks and minerals, *i. e.* inorganic constituents; and—2d, organic substances, *i. e.* such as formed part of some living or organic bodies, but which are now in a more or less advanced state of decomposition and resolution into their component parts. The former, generally speaking, constitute the principal part of the mass of the soil, whilst the latter occur only as an admixture. The process of *degradation* accounts for

the origin of the former; *decay* explains the formation of the latter materials of the soil.

Degradation, we explained, is partly a mechanical, partly a chemical process. The mechanical part is the mere disintegration of rocks and minerals by the influence of water alternately freezing and thawing; the chemical part is the decomposition of the disintegrated rocks, and the formation of their elements into new compounds, for the most part soluble in water. These newly formed soluble compounds mainly engaged our attention, because, as plants are able to withdraw from the soil, and to assimilate as nourishment, only such matters as are soluble in water, these substances are more interesting to us than the far more bulky sand and clay, since these only serve for the mechanical support of the plants. The soluble substances which we thus found in the soil are silicic acid, and several salts, especially carbonates and sulphates, and to the study of these we added an inquiry into the origin of the phosphates. In examining the processes of degradation, it must have struck you that each of the constituents of the atmosphere, except nitrogen and ammonia, must severally take a part in them: so that, had we attempted to ascertain the influence of the atmosphere upon minerals in the aggregate, we should only have confused and obscured the subject.

I shall take this opportunity to add a few remarks to what I have already advanced, with respect to the phosphates.

If you inquire, what are the characteristic properties of the various phosphates occurring in nature as minerals, you will find that they are all, without exception, insoluble in water; and it may justly excite your surprise that they are absorbed by plants, and your curiosity to know in what manner. This is, however, easily explained by the presence of the alkaline carbonates, and also by that of ammonia, combined with the carbonic acid of the atmosphere, since we find that by the action of these substances upon the phosphates of lime and magnesia (and these occur most frequently in nature), soluble phosphates and insoluble carbonates are formed. Thus, for example, when we bring the insoluble phosphate of lime into contact with the soluble carbonate of potass, or carbonate of ammonia, the result is the formation of insoluble carbonate of lime and soluble phosphate of potass or ammonia. A knowledge of this fact is of importance, as it gives us an insight into the mode of action of bone-dust when used as manure; but we shall have occasion to recur to this hereafter. Phosphate of lime, the principal constituent of bones, is insoluble in water, but the ammonia of rain-water, together with the carbonic acid of the atmosphere, decomposes this salt, slowly but surely, giving rise to the formation of a soluble phosphate which may be absorbed by plants. And I may also mention in illustration, that the same process takes place with another salt of frequent occurrence in the soil, but of very difficult and scanty solubility, namely, *sulphate of lime*, or *gypsum*. This substance is also easily decomposed by carbonate of ammonia, and produces soluble sulphate of ammonia. Thus we see that the atmospheric ammonia also takes a part in the decomposition of minerals, and that nitrogen is the only inactive constituent of the atmosphere in the process of degradation.

Finally, I must remark, that the process of degradation, the disintegration and decomposition of rocks and minerals into soil, is not confined to mountain masses, but its operations proceed continually upon the smallest fragments of rocks and stones, mixed with the soil in the fields. I shall, in a subsequent Lecture, show you that *fallow*, in agriculture, is the means employed to ensure the speedy degradation of those parts of the soil which are liable to these processes.

Having made you acquainted with the origin of the inorganic constituents of the soil, and the processes by which they are fitted to become the support of vegetable life, we proceeded to consider the decay of organic substances, and in order to understand it the more perfectly, I explained to you, in detail, the phenomena of combustion, carbonization and putrefaction. This was necessary, in order to render the formation of water, of carbonic acid, and the residuary carbonaceous substance, *humus*, intelligible to you; and, moreover, this full exposition of the process of decay served to elucidate the *properties* of humus. You might, perhaps, have readily accepted my mere assertion, that humus is constantly absorbing oxygen from the atmosphere, and evolving carbonic acid; but I deemed it indispensable that you should know somewhat of the cause, as

well as the necessity, of the phenomena. In the further study of humus, I detailed numerous experiments, proving the opinion very generally held, respecting the solubility of humate of lime, and its absorption and assimilation by plants, to be altogether erroneous, and groundless. We are, therefore, compelled to look for some other explanation of the favorable influence of lime upon vegetation, than the formation of humate of lime; for that lime does exert such a favorable influence is admitted on all hands. Now, although an explanation of the true action of lime belongs more properly to a future lecture when we shall treat of manures, it is, nevertheless, as well to give you now, at once, the substance of the opinions of chemists upon this point, at least so far as relates to the action of lime upon humus.

It is a very well known fact, that when any organic substance, whether animal or vegetable, is brought into contact with lime, it is rapidly and completely destroyed; the same happens with respect to humus. It has been proved by numerous experiments, that alkalies act upon all vegetable substances, constituted like vegetable fibre, so as to produce a rapid formation of carbonic acid, and absorption of oxygen; in a word, they greatly facilitate their *decay*. Now, lime is very similar in its properties to the alkalies; it is the link which connects them with the earths, and, therefore, it is natural to expect it should have an analogous effect—that it too, should facilitate the decay of organic matter. And if, from the process of decay in these substances, proceeding at its ordinary rate, benefits accrue to vegetation, these benefits will, in many cases, be considerably increased by the acceleration of the process, by means of lime.

This, Gentlemen, is the only explanation of the action of lime upon humus, which will bear the test of a rigid examination, and I should advise you to receive with caution, and submit to the most careful scrutiny, by experiment, any other which you may hear proposed; not because you are called upon to submit implicitly to this or that chemical theory, but because, at the present day, agriculture should be practised only on well-established scientific principles.

To return to our recapitulation, after this short digression, it only remains for me to remind you, in conclusion, of the formation of ammonia in every case of decay, from the nitrogenised constituents of plants. Every plant containing more or less nitrogen, the humus derived from them must always contain more or less, which, during its decay, passes off in the form of ammonia. Of course the humus, which is formed by the decomposition of animal substances, must produce far more ammonia than pure vegetable humus, animal substances being far richer in nitrogen than vegetable bodies. In a subsequent lecture, when treating of manures, we shall recur to this subject, and I shall then treat of the ashes contained in all the various kinds of humus, of the importance of which you can only become aware hereafter.

You have now, Gentlemen, learned what are the materials which the air, the water, and the soil, severally and collectively proffer to the use of plants. We have now to endeavor to ascertain which of these materials plants require and appropriate. In order to answer this question, it is necessary, in the first place, that we should know the *composition* of plants, in order to save ourselves from entering into idle speculations. Because it is evident if we do not detect a trace of *sand*, for instance, in any plant, we may safely infer that the sand of the soil contributes nothing towards the nutrition of plants.

The constituents of plants may be considered under two heads: 1st, the immediate; and 2nd, the ultimate. The first, proximate or *immediate* constituents of plants, you must understand, are those which, upon examination, become immediately apparent. For instance, if I examine a leaf of any tree, I find its component parts to consist of vegetable fibre, a peculiar coloring matter imparting its green color to the leaf, vegetable albumen, starch, water, various salts, &c. But all these substances are compounds, and in order to ascertain of what they are composed, it is necessary to subject them severally to a special chemical examination. The substances which a chemical investigation, or analysis, shows to be their component elements, are denominated the *ultimate* or elementary constituents of plants. Moreover, none of the proximate or immediate constituents of plants are contained in air, water, or soil, but they are the products of vegetable life, which plants can produce only when the ultimate elements are supplied to them. It is, therefore, evident, that the latter or the ultimate elements of plants

are alone to be considered as the subject of Agricultural Chemistry. And our first inquiry will consequently be, what are these constituents? and the second, whence do they originate—what is their source and origin?

What are the remote or elementary constituents of plants?

Of a great number of elementary bodies known to chemists, only a few enter into the composition of plants, to form their ultimate constituents. The immense variety in the immediate constituents of plants depends upon the various proportions in which a few of the ultimate elements combine with each other. As an illustration of this point, compare a piece of sugar with woody fibre. These two substances differ very widely in appearance and in properties, and yet they consist of the same elements—namely, carbon, hydrogen and oxygen. The difference between sugar and woody fibre depends upon the difference in the relative proportions in which these elements are combined with each other in the two substances.

The ultimate elements met with in plants are the following: carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, iodine, bromine, potassium, sodium, calcium, magnesium, iron, manganese, and silicon.* I deem it necessary to make you somewhat acquainted with these elements, some of which are, at present, wholly unknown to you. The number of elements known to chemists are at present fifty-six. You perceive, therefore, that only a few of them, namely sixteen, enter into the composition of plants. Four of these sixteen elements we have already treated of; namely, carbon, hydrogen, oxygen and nitrogen; and three others—sulphur, iron and phosphorus—I suppose are sufficiently familiar to you to require no further description; and a very brief notice of the remaining nine will serve to enable you to obtain an adequate knowledge of them for our present purpose. Silicon, although unknown to you in its elementary or uncombined state, is known to you in silicic acid, and as the basis of flint.

Potassium and sodium are two metals, which, in combination with oxygen, form two basic substances, soluble in water, denominated *alkalies;* these you know as potass and soda. The potass and soda of commerce are carbonates of these bases. Calcium and magnesium are also two metals, the compounds of which with oxygen are known under the names of lime and magnesia. Manganese is also a metal invariably occurring in nature in connexion with iron, and possessing very analogous properties to those of iron. Finally, chlorine sodium and bromine, strictly speaking, are important only to marine plants. Chlorine, combined with hydrogen, forms hydrochloric acid—a substance we have spoken of already; with sodium, it forms common culinary salt. This is all I need say with respect to the elementary constituents of plants, to enable you to understand the necessity or some of them in cultivated plants.

These sixteen elements may be appropriately divided into two classes. Several reasons might be given for this classification. I shall content myself with one; namely, their behavior in combustion and decay. Upon burning a plant or part of a plant, or exposing it to complete decay, certain of these elements invariably combine with each other, forming new compounds, which being volatile, intermix with the atmosphere; whilst others, not being volatile, remain after combustion as ashes, or after decay in the soil, as salts. We will, therefore, if you please, designate the former as *volatile*, and the latter as *fixed* constituents of plants. But I must tell you, other principles of classification are adopted by Authors; but, after all, they resolve themselves into a mere difference of terms. Thus you will find the elementary constituents of plants divided into *general* and *special;* but, at the same time, you will observe that their general constituents correspond exactly to those I denominate volatile, whilst their special constituents are precisely the same as those I call fixed. Again, if you like it better, you may adopt the designation atmospheric constituents, for the first class, and mineral or earthy constituents, for the second class; because, as you will find hereafter, the first class are derived from the atmosphere, and the second from the soil.

The volatile, atmospheric, or general constituents of plants, the elements of

* "Fluorine has been recently found to be a constituent of the ashes of plants; it occurs in the teeth and bones of animals, having been derived by them from vegetable food; it will doubtless, therefore, exist still more abundantly in the ashes of plants. It almost constantly accompanies phosphoric acid, and is as generally diffused on the earth's surface as that acid itself, which is so indispensable both for the vegetable and animal kingdoms."—[Dr. H. Will.

the first class, are four in number—carbon, hydrogen, oxygen, and nitrogen. And now, before answering the question, Whence do plants derive their volatile constituents? or attempting to make you further acquainted with those elements with which you are not yet familiar, as potassium, &c., I purpose to give you some notion of the method adopted by chemists to ascertain exactly how much a plant contains of the four volatile elements, carbon, oxygen, nitrogen and hydrogen.

I have already informed you, that in the complete combustion of an organic substance, that is, its decomposition by heat, with the access of a sufficient amount of oxygen, all its volatile elements escape into the atmosphere under the form of carbonic acid, aqueous vapor, and free nitrogen; and that the last element, under certain circumstances, passes off as ammonia. Now, it is evident that if we collect all the carbonic acid produced in combustion, and bring it into such a form as to enable us to weigh it with accuracy, we shall be able to determine the exact amount of carbon contained in a given weight of any organic body. In like manner, we must be able to determine its exact amount of hydrogen, by condensing all the aqueous vapor formed during combustion, into water, and carefully weighing this water.

Of the methods of determining the amount of the oxygen and the nitrogen, we shall speak hereafter. In one word, it is only necessary that we should not allow any of the products of combustion to escape into the atmosphere, as is usually the case when we employ the process of combustion only for the heat evolved, and disregard all the ponderable products of the process.

An apparatus has been recently invented, which answers perfectly every condition thought by chemists necessary for the collection of each and every product of combustion. It is called "an apparatus for the combustion of organised substances." This contrivance is a no less important acquisition to science than the telescope or microscope; the most ingenious chemists of our age have applied all their skill to bring it to its present state of perfection; and the science of organic chemistry, with all its bearings upon science, arts, and manufactures, depends entirely upon this invention for its recent achievements and for its hopes of advancement. With respect to the confidence we ought to place in results obtained by means of this apparatus, it may be safely asserted, without fear of contradiction, that no mechanism has ever been contrived which so perfectly accomplishes the object it is designed to effect as this apparatus for the combustion of organic substances. And we ought to yield our unhesitating acquiescence to the results obtained by its means in the hands of a skilful chemist, as confidently as we trust to the predictions of the astronomer.

LECTURE VIII.

ON THE CARBON OF PLANTS.

Whence do Plants Derive their Carbon?—From Humus? or from Carbonic Acid?

Gentlemen:—An inquiry into the source of the carbon which forms so large a proportion of the whole bulk of vegetable substances, is one deserving of your careful and minute attention, not because it involves any very recondite study, but inasmuch as the opinions which I shall have occasion to express respecting it are opposed to those which have hitherto prevailed amongst agriculturists.

I may, I trust, assume that none of you for a moment believed that plants possess the power of producing carbon, or any substance containing carbon, out of nothing, or of transmuting other elements, such as hydrogen, nitrogen, &c. into carbon. I have already had occasion to tell you that there is not one single fact in the whole range of science to support such a notion, to render it *probable*, or even to suggest the *possibility* of such a transformation of elements. This being admitted, it follows of course that plants must derive their carbon from substances surrounding them.

In the second place, we know that, with the exception of carbonic acid and

humus, no carbonaceous substances exist in the atmosphere, in the water, or the soil. It is, therefore, obvious that our inquiry is limited to the question, whether plants derive their carbon from the carbonic acid or the humus, or from both?

I will endeavor first, to answer the question whether plants possess the power of absorbing *humus* by their roots from the soil? and to consider the facts which appear to favor the assertion that humus *is* necessary for the supply of carbon for the nutrition of plants, and those facts which appear to prove that it is *not* necessary; I will then follow the same course with respect to carbonic acid, and from both classes of facts endeavor to deduce a correct conclusion.

Are plants able to take up from the soil humus or a soluble humate? This question must be at once answered in the affirmative; because we know that plants absorb *everything* soluble in water coming within reach of their roots. We know, indeed, enough of the structure of plants to believe it probable that they will absorb a solution of any substance whatever in water, provided the solution do not absolutely destroy the tissue of the plant. But it is quite certain the mere absorption of a substance by a plant does not prove that it is employed for the nourishment of the plant; on the contrary, plants cast off what is useless to them, and there are many ways in which they effect this, even (as experiments have shown) giving such matters back to the soil whence they were derived. No one doubts that plants will absorb humus and the humates, more than we can doubt that they will absorb blue vitriol, when brought in solution into contact with their roots. But this is not our present question. What we want to know is, whether humus or humates contribute by their carbon to the nutrition of plants, or not? The well-known effects of animal and vegetable manures seem to prove the affirmative of this question. We know that humus is produced by the decomposition of vegetable and animal substances; and thousands of years' experience has proved the luxuriant growth of plants in soils supplied with such manures, and consequently rich in humus. But this does not prove that it is the *carbon* of the humus to which the fertilising effects of manures are to be ascribed; those manures contain a great many other matters besides carbon to which the nourishment and growth of the plants may be probably attributed, and of these we shall speak by and by. But that the carbon of plants is not derived from humus or the humates in the soil, is manifestly proved by the facts. Seeds have been planted in pure sand, and in artificial soils containing no humus; and yet these seeds have germinated, and plants have grown from them: although they certainly do not attain a complete development, so as to produce new seed, yet they are found to contain carbon. Perhaps you may object, that the seeds themselves contained carbon—true; but the amount of carbon in the plants far exceeded that of the original seeds. There must, therefore, exist some other source of carbon than humus. You must have often seen the bulbs of hyacinths, placed in water only, produce stem, leaves, and flowers in abundance; these contain carbon; and yet no humus being present, they could not derive it from humus. We need not, however, confine ourselves to these insignificant examples, since Nature affords us proofs of the same truth upon a far greater scale. I allude to forests, and especially those of pine. Observe the vigorous growth of these trees, even in the most sandy soil; nay, you may see pines of almost gigantic growth, with roots fixed in the clefts of rocks composed of nearly pure sandstone. Whence do these trees derive their carbon? Certainly not from the soil, because this contains humus only in such insignificant proportions that but a few ounces could be found in the space occupied by a single tree, whilst the weight of the carbon contained in the tree itself amounts to many hundred-weights; and as it is with an isolated tree, so it is with forests extending over many square miles. Even the minute proportion of humus contained in the soil of these forests is owing to the decomposition of part of the trees themselves, their twigs, branches, leaves, and cones, or of small shrubs growing beneath them; and the carbon of this humus, therefore, must be added to that of the trees which is to be accounted for. Whence is all this carbon derived? Not from the humus of the soil, for the quantity of this goes on increasing as the growth of the forest advances, instead of becoming exhausted. Look, again, at your meadows!—what an immense amount of carbon you carry off from them, every year, in the form of hay! How do you replace that carbon? Perhaps you may think that the roots of the grass decaying in the soil are its source; but

whence do these roots derive it? You perceive that with the humus theory we go round in a circle—we make no advance toward an explanation of the source of carbon; and very little reflection is sufficient to prove it groundless.

I have frequently seen laborers in the Alps, at the risk of their lives cutting grass in places where no cattle would venture on account of their steepness, consequently where no manure could ever be applied, and yet the grass is cut year by year. The humus in the soil cannot be very abundant on these acclivities, as the bare rocks are every where visible. We can very easily make a calculation of the amount of carbon drawn from the surface in the shape of hay, and this will show how very soon the soil would be exhausted were this carbon derived from the humus contained in it.

Further, do you think that the humus of the manures which you annually spread over your fields, contains as much carbon as you carry away in your crops of corn and other productions?

I may suppose that, guided solely by your experience, you really think this to be the case, since you well know that he who carries much manure upon his fields will obtain a plentiful harvest. And yet you are mistaken in this matter. The amount of carbon in the crop invariably exceeds that of the manure. This is not a mere vague supposition, but a fact founded upon exact and repeated chemical investigations of the manure and the corresponding harvest. It is, therefore, certain, that if the whole amount of humus of the manure yielded all its carbon to the plants, there must still be another source of carbon, whence the plants receive a supply. Thus you perceive experience seems to disprove the opinion, that humus, as such, serves to supply carbon to plants.

But we may proceed, in another way, to arrive at the same conclusion. Let us, for the sake of argument, assume the carbon in the crops to correspond with that of the manure; or even let us suppose the latter to exceed all the carbon of the harvest, although, as we have repeatedly observed, such assumptions are opposed to the most conclusive experiments and investigations. If humus or humates are to be absorbed by plants, it must be while they are in a state of solution; since we know, that plants are unable to absorb any substance unless it is dissolved. But here we meet with this difficulty: humus itself is very slightly soluble, and such humates as are soluble are not found in the soil. So that if we suppose a soil to contain so much humus that its carbon would be sufficient to supply the wants of the crop, it would require so great an amount of water to dissolve this humus, that all the rain falling during the summer would not suffice. Thus, even were humus present in abundance, yet a solvent would be needed to make it available for supplying plants with carbon. It must not be objected that this is mere supposition, since we cannot measure the amount of rain falling annually upon a given surface; because we possess, in the rain-gauge, the means of ascertaining with great accuracy the quantity of rain falling upon any area in any given time, and, therefore, since we know the exact quantity of water required to dissolve a certain amount of humus, we can, by a simple calculation, discover that the quantity of rain falling to the share of any given tract of land during the summer months is insufficient to dissolve as much humus as would be required to furnish the carbon of the plants growing upon that tract.

If, therefore, we can prove—1st. That plants obtain carbon when there is no humus in the soil in which they grow: 2nd. That when humus is present in the soil, the carbon contained in plants is more than the total amount contained in that humus: 3rd. That the carbon withdrawn from the fields, in the crops, invariably exceeds that contained in the manure: 4th. That no easily soluble humates are present in the soil: 5th. That the humus and humates actually present, require far more water for their solution than the total amount of rain falling during the year; and finally, 6th. That the amount of humus, and consequently of carbon, in the soil may increase from year to year by vegetation, and without manures:—if we can satisfactorily prove all this, it can no longer be admitted that humus is necessary to vegetation; at least it cannot be the source whence plants derive the carbon essential to their existence and growth.

Having arrived at this inevitable conclusion with respect to the humus of the soil, it remains to be decided whether the carbonic acid of the atmosphere is

adequate to the supply of the carbon necessary for vegetation. And here I shall candidly consider the facts, both for and against this supposition.

If the carbon of plants must have some origin in substances surrounding plants, and if we have proved it is not derived from humus, there remains no other carbonaceous substance in contact with plants than the atmospheric, carbonic acid, and consequently this must be its source. If we consider the universal presence and great solubility of carbonic acid in water, this inference is rendered highly probable. I have shown you, in a previous lecture, that carbon is constantly supplied to the atmosphere, and that it is found in every kind of water. No one has ever attempted to prove that a plant can grow if the access of carbonic acid to it is completely excluded. Again, it has been established beyond a doubt, by a host of experiments and observations, that plants give out oxygen, whilst they absorb carbonic acid ; an evident proof of a chemical process, which admits of no other explanation than this, that the carbonic acid absorbed is used for the formation of the carbonaceous proximate constituents of plants ; water is thus decomposed, and consequently oxygen liberated.

Permit me, Gentlemen, to quote an experiment of Schleiden, made with a view to prove that the carbon of plants is derived from the carbonic acid of the atmosphere, which I will do in his own words :—

" Notwithstanding the immense number of works upon the nutrition of plants, nothing can be more inconsistent than the views entertained as to what matters are really required by plants for their nourishment. The reason is obvious. Inquirers and experimentalists have begun at the wrong end ; they have made experiments, and have speculated upon the most highly-organised, the most compound plants, instead of looking first for the laws which govern the nutrition of the most simple. The best and most natural object for an investigation of this kind is the Protococcus viridis, or some other of the confervæ, plants consisting of one cell, or a few cells united, but at the same time containing all the elements essential to life in the cell. These plants live in pure water, and require nothing more for their support than water containing carbonic acid and ammonia, derived from the atmosphere, and perhaps a minute amount of inorganic salts ; the necessity of the latter is by no means proved, but only supposed, according to the analogy of plants of a higher order.

Take one of these plants, and place it in water ; impregnate this water constantly with carbonic acid gas, which may be conveniently done by connecting it with a vessel containing matter in a state of fermentation, and you will see that the growth of the plant will be brisker and more luxuriant than if you place it in water mixed with humic acid and the humates. In water containing these latter substances, these plants do not even grow so well as in pure water. This is quite sufficient to prove how unessential these substances are for the life of the cell."

We might now, I think, very safely pronounce our opinion in favor of the supposition that the carbon of plants is derived from the carbonic acid of the atmosphere ; but, in order to proceed with caution, and to answer the inquiry with strict impartiality, we will examine the objections which may be made to this view.

Soon after it had been ascertained that the liberation of oxygen under the influence of light upon plants stood in close connection with the absorption of carbonic acid, it was also discovered that the same plants absorb oxygen during the night, and give off carbonic acid. And, without further examination—without attempting to ascertain the relative proportions of the carbonic acid and oxygen absorbed and given off—there were persons who immediately, and without hesitation, asserted that the oxygen absorbed at night must be the same which had been liberated during the day, and the carbonic acid set free at night must be the same which the plant had absorbed during the day. You will understand, if this explanation were true, there would be an end to our opinion respecting the derivation of the carbon of plants from the atmosphere. But it is not so. I do not mean to dispute the fact of the nocturnal absorption of oxygen, and liberation of carbonic acid, but it has been proved by experiments that the amount of oxygen given off by plants during the day is much greater than that absorbed at night. So that the production of an atmosphere richer in oxygen than common air, is the necessary consequence of vegetable life. The following experiment will demonstrate to you the truth of this remark :

A piece of grass-plat, about four inches square, was cut out from a meadow, placed in a porcelain basin, and floated upon water in a larger vessel; a large glass jar was inverted over the basin in such a manner as to include, with the grass, a definite amount of air, namely 230 cubic inches, and to cut off its communication with the atmosphere. The grass was from time to time moistened, and carbonic acid added to the water in which the basin was swimming. After the lapse of eight days, during which time the grass had of course been exposed to the alternate influences of day and night, the volume of the air under the jar had increased by 30 cubic inches, and, upon examination, was found to possess 4 per cent. of oxygen more than the external atmosphere. Now, this could not have happened had as much oxygen been absorbed at night as was liberated by day. The same remark is applicable to the carbonic acid.

The following simple exposition will, I trust, render perfectly intelligible to you the relation of the diurnal and nocturnal processes of emission and absorption which plants undergo.

At all times during day and night, a mutual and alternate action is going on between plants and the substances surrounding them, and consequently between the constituents of these substances and those of plants. The result of this mutual and alternate action is the absorption and elimination of certain of those constituents. Thus, for instance, many vegetable matters are constantly being united to oxygen, that is, *oxidised*, both during the day and the night. This deprives the atmosphere of oxygen. But during the day oxygen is liberated from plants, under and by the influence of light, to a far greater amount than is fixed in these various vegetable substances as they become oxidised, and consequently, instead of a loss we find a gain of oxygen to the atmosphere. But in the night, the oxygen of the atmosphere is diminished, because the amount received into plants is not restored by its elimination.

Carbonic acid is absorbed by all living plants both night and day, but it is only during the day that it is employed for the nutrition of the plant, under the influence of light, whilst that absorbed at night is returned into the atmosphere with the water, which is continually evaporating from the surface of the leaves. This takes place by virtue of a purely mechanical law, so that there is no reason to suppose that the carbonic acid exhaled by plants during the night, is the same that had been absorbed in the day.

Finally, there is still another objection which may be made to our assertion,—that the carbon of plants is derived from the carbonic acid of the atmosphere,—namely, the minute proportional amount of carbonic acid in the air. In a former lecture I stated this to be no more than 4 volumes of carbonic acid to 10,000 volumes of the atmospheric air; and it may very reasonably be inquired how it is possible so minute an amount can afford the necessary amount of carbon for plants, enormous as this must be? But in truth, this very small proportional amount in the atmosphere is a proof of the fact I am endeavoring to establish. You will recollect what I told you in a preceding lecture, when treating of the atmosphere, of the abundant and inexhaustible sources existing upon the earth whence carbonic acid is incessantly poured into the atmosphere, and yet we find no accumulation of this substance: we must, therefore, naturally look for some cause which counteracts this supply and prevents accumulation; and this cause we assumed to be the absorption of it by the vegetable kingdom; and I think I have now proved the truth of this assumption.

By virtue of the law of the diffusion of gases, as well as by the incessant motion of the air, the carbonic acid withdrawn anywhere is immediately replaced by a new supply, so that it is not necessary that there should be an accumulation of the carbonic acid in the immediate vicinity of plants, in order to render it available to them for nourishment: the proportion actually found in the atmosphere is sufficient for their consumption.

I think we may now safely pronounce that the question, whether plants derive their carbon from the humus of the soil, or the atmosphere, is settled, and that we may be satisfied that it is derived solely and exclusively from the atmosphere without seeking to support this opinion by any further arguments than those already adduced. For we have seen, 1st, that plants may grow without humus; 2nd, that humus, when present, is only found in quantities so insignificant, that its amount of carbon is insufficient to supply the amount found in the vegetables

growing on the soil; 3rd, when supplied artificially with soil in animal and vegetable manures, it still does not amount to so much as is removed from the fields in the harvest; and lastly, if there were a sufficient quantity of humus in the soil, there would not be an adequate supply of water for its solution; hence, we must conclude that the origin of the carbon of plants is not the humus. And then, on the other hand, since, 1st, carbonic acid is in constant contact with plants; 2nd, since no other carbonaceous substance, save carbonic acid and humus, exists in the vicinity of plants; 3rd, since the carbonic acid of the atmosphere is incessantly supplied and renewed; and finally, because plants continually absorb carbonic acid, and give off oxygen, which process is explained by no other supposition, we must acknowledge that the carbonaceous proximate principles of plants derive their carbon from the atmospheric carbonic acid.

It cannot, I think, be doubted, that you now are ready to admit the production of proximate carbonaceous vegetable principles, from carbonic acid; and yet, at the same time, you may still think there is some ground for the opinion which assigns their origin to the carbonic acid and humus, and the humates in common; you may suppose that where these substances are present, they will be absorbed and assimilated, and supply carbon as well as carbonic acid. If I no not mistake, there are but four arguments which may be used to favor this view. 1st. Experiments have been made in which humus and the humates have been absorbed by plants, and have been actually detected in them. 2nd. The almost universal presence of humus in the soil where plants are grown. 3rd. The effects of animal and vegetable manures; and, 4th, the favorable action of lime upon soils rich in humus.

I will endeavor to convince you that most of these facts, which are adduced to prove the derivation of carbon from humus, tend on the contrary to support our own opinion. First, it may be granted that humus and the humates are absorbed by plants; but plants also absorb solutions of sulphate of copper and salts of silver, and we can detect such salts in the plants. Would you conclude from this that salts of copper and silver are nourishment for plants? Certainly not. Plants will absorb anything soluble, which does not destroy their tissues, and, therefore, they will absorb humus and the humates; but as these may be traced in the juices of the plants which have absorbed them, this seems rather to prove that they are not decomposed, and consequently, that they are not employed for the formation of proximate carbonaceous constituents. Secondly: the invariable presence of humus in the soil where plants are growing, only proves there is some connexion between plants and humus. What is it? The leaves, twigs, and branches fall off, the roots of perennial plants remain in the soil, and there decay and form humus. Its coëxistence with plants, therefore, proves nothing for the opinion of the nutrition of plants being derived from it. Thirdly: as to the effects of manure, our assertion, that the carbon of plants is not derived from humus does not oppose the truth of the favorable action of manure.

Does manure contain no other substances useful to vegetation than carbon? Ought we to overlook the property of decaying manure—of humus—to absorb water and the other constituents of the atmosphere, and to consider exclusively its amount of carbon? Manure and the humus derived therefrom cannot supply carbon to plants,—as carbon,—it can only, by its decomposition, give rise to the formation of carbonic acid, and thus increase the amount of carbonic acid present in the immediate vicinity of plants. And it remains to be proved that this is of any value to plants, that the amount in the atmosphere is insufficient to supply their demand for carbon. And, in my judgment, it is impossible to prove this.

Lastly. With respect to the action of lime upon vegetation, which, as I have already observed in a former lecture, is generally ascribed to the formation of a soluble humate of lime, I must refer you to what I then advanced respecting its favorable effects, merely reminding you that it depends partly upon the supply of the lime necessary to plants, since a certain amount enters into their constitution, and is necessary to their existence, partly upon its facilitating the progress of decay, and the resolution of humus into carbonic acid, and partly upon its action upon the silicates of the soil giving rise to the formation of soluble silicic acid.

LECTURE IX.

THE OXYGEN, HYDROGEN AND NITROGEN OF PLANTS.

Origin of these Elementary Constituents of Plants.... Whence do Plants derive their Nitrogen? Whether from the free Nitrogen of the Atmosphere? or from the Nitric Acid? or the Ammonia?.... Origin of the Sulphur and Phosphorus of Plants.

GENTLEMEN:—When we inquire, as we now propose, whence do plants derive that oxygen, which, upon examination, we find in all their proximate constituents, although in various proportions, the answer which seems, upon a superficial view of the matter, most obvious, is, that it is derived from the atmospheric oxygen. This, is, indeed, the more plausible, because oxygen exists in the atmosphere uncombined, unfettered by any chemical affinity, and being always available for the various processes of oxidation. But if I remind you that vegetable life is incessantly operating to increase the amount of oxygen in the air, you will easily conceive that the atmospheric oxygen cannot contribute towards the nutrition of plants, that is, it cannot assist to form their proximate oxygenous constituents. You will recollect that in my last lecture I described to you an experiment which directly proved the augmentation of oxygen in the air by vegetable life.

There must, therefore, of necessity exist some other source of oxygen, and for this we can only look to substances existing in the vicinity of plants, and containing oxygen.

Upon examining all these oxygenous substances, our attention is at once drawn to water and carbonic acid. These two compounds are invariably present in the vicinity of every plant, and are as invariably absorbed by plants. If we carefully compare and consider the reasons which may be urged in favor of either of these two bodies, we shall arrive at the conviction that the sources of the oxygen of plants must be exclusively ascribed to the carbonic acid. This conclusion, indeed, rests upon considerations belonging to the science of chemistry: to enter into any satisfactory detail, or attempt a full exposition of the proofs of this opinion, would lead us too far into that science. You may safely accept this as an established truth, because, were the contrary proved, it would not be of the slightest importance either in theoretical or practical agriculture. It is no matter whether the oxygen be derived from the carbonic acid or from the water, since both these substances are absolutely necessary to vegetation, the carbonic acid as a source of *carbon*, the water as a source of *hydrogen*.

With respect to the origin and source of the hydrogen of plants, we are limited (with the exception of the small amount of hydrogen contained in the nitrogenized constituents of plants) exclusively to water, as the substance capable of furnishing that element. For since, as I intend hereafter to show more fully, ammonia and water are the only substances, containing hydrogen, capable of being absorbed by plants, and yielding hydrogen for their nutrition, and since the ammonia can only be considered adequate to supply the hydrogen of the nitrogenous constituents of plants, and since these constituents form but a very small proportion of their substance, the non-nitrogenized being almost the entire plant, we may admit, as an established fact, that the hydrogen of the bulk of the proximate constituents of plants is derived from water which is decomposed under the influence of light, carbonic acid being at the same time present. You will from these remarks understand that it is in consequence of this decomposition of water in the vital processes of plants, that they constantly yield oxygen to the atmosphere.

The question—*whence do plants derive their Nitrogen?*—cannot be so easily answered as the preceding, respecting the source of hydrogen and oxygen.

Our views upon this point, being founded upon observation and experience, are worthy of your most serious consideration. It is not a matter of indifference, either in a theoretical or practical point of view, whether nitrogen be derived from one substance or another; on the contrary, it is of the highest importance in the practice of agriculture, that you should know whether the nitrogenous

constituents of plants are formed from the free nitrogen of the atmosphere, or whether the source of their nitrogen is the ammonia, or any other substance.

The nitrogen necessary for the nutrition of plants, and for the formation of their proximate constituents containing this element, may be derived, 1st, from uncombined atmospheric nitrogen; 2ndly, from nitric acid; 3rdly, from ammonia; or 4thly, from humus; for we have seen that the nitrogenous substances in plants invariably have a share in the formation of humus, and, moreover, humus is formed also from animal substances used as manure.

We will now examine separately these four possible sources of nitrogen.

A superficial view of the matter must first necessarily excite attention to the free and uncombined nitrogen of the atmosphere; and the opinion has been adopted by many persons, that this nitrogen is the source of all which is found in the nitrogenous proximate constituents of plants. But if you will call to mind what I stated in a former lecture, respecting the inertness and indifference of nitrogen in certain chemical processes occurring in nature,—the difficulty of artificial processes for producing nitrogenous compounds,—and the readiness with which they are decomposed,—I think you will perceive that it is not at all probable that the free nitrogen of the atmosphere is the source whence this element is derived for the nutrition of plants. If to these considerations we add the results of certain experiments made by De Saussure, who proved that plants kept in pure nitrogen, or in a limited quantity of atmospheric air, did not diminish the amount of the nitrogen, we may be perfectly assured that the uncombined atmospheric nitrogen is not the source of the nitrogen of plants.

With respect to the second possible source of nitrogen, namely, the nitric acid of the atmosphere, or the nitrates of the soil, I do not think the possibility of the nitrogen of plants being derived from the decomposition of nitric acid would ever have been suggested, had not those persons, who have supposed this to be its source, been ignorant of the existence of ammonia in the atmosphere; because, whilst ignorant of the existence of this latter constituent of atmospheric air, and yet convinced that the free nitrogen could not be its source, they were driven to the supposition that plants must receive a supply, for the formation of nitrogenous constituents, from nitric acid and the nitrates. And when this opinion was once broached, observations and experiments were not wanting, which seemed to prove its correctness. First, it has been long observed that vegetation becomes obviously more luxuriant after thunder-storms, and in the rain accompanying these, nitric acid is found, as I have already told you. Secondly, the vigorous growth of weeds upon heaps of rubbish seemed also to confirm the same idea, because nitric acid is found in this rubbish. Thirdly, experiments have been made with nitrates, and the favorable action of these salts upon vegetation, especially upon the growth of grass, seemed to establish the opinion in question. But whilst we cannot deny the favorable influence of the rain of thunder-storms, or the luxurious growth of weeds upon heaps of rubbish, these phenomena admit of a better explanation than by supposing them to arise from the decomposition of nitric acid.

For, in the first place, the minute proportion of this acid present in that rain, and, secondly, the accompanying circumstances of the fall of that rain, render it highly improbable that its favorable influence upon vegetation is to be attributed to its supplying nitrogen to the plants. We must recollect that it usually falls after a season of dryness, and renders soluble the constituents of the soil needed by the plants for their development, at a time when they are most in want of them; and we shall be led to conclude that this opportune supply of water alone is quite adequate to effect the observed improvement in vegetation, and fully explains all that needs explanation in the matter. As it cannot be proved that the nitric acid causes all the favorable influence observed, so neither can it be proved that it has any share whatever in the phenomena. With respect to the second point, namely, the luxuriant growth of weeds on heaps of rubbish, or upon soil rich in nitrates, there is no reason to infer that the necessary conclusion must be, that these are the cause of the vegetable growth; on the contrary, it appears most likely that the luxuriant vegetation, and the presence of the nitrates, owe their origin and formation to one and the same cause, namely, the decay and putrefaction of nitrogenous animal matters present in the rubbish or soil. If the process of decomposition gives rise on the one hand to the formation of nitrates,

(alkaline substances being present,) as one class of its ultimate products; so, on the other hand, it at the same time converts certain constituents of the soil, indispensable to vegetable life, (as the phosphates and other salts,) into such forms as to render them capable of absorption and assimilation by plants, not to dwell upon the more abundant formation of carbonic acid and ammonia. So that we need not be surprised to find at such spots nitrates in the soil, combined with a luxuriant vegetation; and yet there is no reason to suppose the latter to depend upon the former as its cause.

Thirdly and lastly, the experience of practical agriculturists may be referred to; since many of them, it is said, have secured a more abundant crop, and especially upon meadows, by employing nitrates, and usually nitrate of soda, as manure. If you are disposed to think that this favors the assumption of the derivation of the nitrogen of plants from nitric acid, I must beg you to remember, that by manuring meadows with calcined bones or wood ashes, and the like substances, containing neither nitrogen nor nitrates, the produce of the meadows has been doubled and even trebled. So that the increase of the produce, by the application of nitrate of soda, does not prove that it is from the nitric acid yielding its nitrogen to the plants, but that it may be solely from the presence of the soda that the crop has increased.

Thus, Gentlemen, you will, at least admit that these observations and experiments do not render it certain that the nitrogen of plants is derived from nitric acid. On the contrary, if you take into consideration that nitrates occur but rarely in the soil, nay, that not a trace of these salts can be detected in many places where plants flourish and produce nitrogenous constituents, it must be evident to you that this nitrogen must be derived from some other source, and that *ammonia* alone can be that source.

But, besides these negative proofs of the derivation of nitrogen from ammonia, there are many of a positive kind to justify this conclusion. In the first place, ammonia is invariably present as a constituent of the atmosphere, and consequently in immediate contact with all plants. Secondly, ammonia is of such ready solubility in water that, as I have already proved to you in a former lecture, it may be detected, not only in rain-water, but in every kind of water whatsoever; so that, together with water, ammonia is constantly conveyed into the growing plant. Thirdly, the chemist,—who assuredly knows best the mode and result of the decomposition of various substances,—has nothing to urge against this assertion of the derivation of nitrogen and the formation of the nitrogenous constituents of plants from ammonia; his experience teaches us how easily ammonia is decomposed. Finally, this view of the source of the nitrogen of plants is confirmed, in the most conclusive and satisfactory manner, by practical experience; and you, Gentlemen, I presume, will be disposed to rely more confidently upon this kind of evidence than upon any other.

I have already explained to you in what manner the decay of nitrogenous substances gives rise to the formation of ammonia. And I have already endeavored to leave no doubt upon your minds that it is to this process of decomposition that we must ascribe the incessant formation of ammonia and its supply to the atmosphere, so as to maintain its presence as a constant constituent therein, notwithstanding the continual withdrawal and absorption of it by plants.

Now, when nitrogenous substances are undergoing the process of decomposition, and an abundant formation of ammonia is taking place in the immediate vicinity of growing plants,—the other conditions of vegetation being fulfilled,—we may anticipate, not only that the plants will grow more luxuriantly, but that they will contain a larger amount of nitrogenous constituents than plants growing elsewhere, without so liberal a supply of ammonia. Practical experience confirms this theoretical assumption. In all cases where chemical investigations have been made upon this point, it has been found true. Thus, wheat, which had grown upon a spot where very little ammonia was formed by the decomposition of organic substances, was found to contain only 12 per cent. of gluten (its nitrogenous constituent); whilst wheat grown where ammonia was abundantly evolved during its growth, contained 35 per cent. of gluten. In the first case cow-dung was employed as manure, which is very poor in nitrogenous matter; in the second, human urine, a substance which of all animal excretions yields the largest amount of ammonia.

I think you cannot need any more decisive proof of the importance of ammonia for the nutrition of plants, so far as the supply of the necessary nitrogen is concerned.

And I trust, also, that this illustration has removed from your minds any prejudice which you may have imbibed respecting Chemistry, since I know, that it is supposed to be the tendency of Chemistry to teach you to look with suspicion upon the alleged beneficial influence of manures upon vegetation. The favorable action of animal and vegetable manure, is a fact confirmed by the experience of a thousand years; and chemists have certainly, therefore, no wish to abolish manures!

The science of Chemistry, Gentlemen, seeks to teach you in what manner manures act; which of their constituents are useful to plants; and in what *form* the materials, drawn from them by plants, enter into, nourish, and promote their growth. Although Chemistry has refuted the *humus theory*, that is, the opinion which ascribes to humus not only the principal share in the nutrition of plants, but especially the production of their carbonaceous proximate constituents, it does not follow, that humus exercises no influence whatever upon the development of plants, and especially of the cultivated plants. But I have not yet had an opportunity of explaining to you the nature and extent of the influence of humus, a subject I shall treat of in a future lecture, when we come to the subject of manuring.

I have now pointed out to you the sources of the four principal constituents of plants, which I have called general or atmospheric constituents. It cannot have escaped your notice that all the substances from which the are derived, are constituents of the atmosphere; so that no plant can grow without the access of atmospheric air and carbonic acid; water and ammonia must also be invariably present. The vegetation of aqueous and marine plants without the access of the atmosphere, is no objection to this assertion, since you know that all the constituents of the atmosphere are soluble in water, and can always be traced in it in solution; and hence these substances are always present for marine plants to draw from them their oxygen, carbon, hydrogen, and nitrogen.

Before entering upon the consideration of the constituents of plants derived from the soil, properly speaking, I will here discuss the origin of two more of their ultimate constituents, namely, sulphur and phosphorus. These two elements occur in all plants, and this under a twofold form: 1st, combined with the four atmospheric constituents, so as to form a *proximate constituent*, namely, vegetable albumen, which is present in every plant; and 2d, we find them in the juices of plants, as sulphuric and phosphoric acids combined with bases, forming salts. Now, inasmuch as we may safely assume sulphates and phosphates to exist in every soil, we have no difficulty in accounting for their origin as constituents of plants; they are derived from the soil, and upon the decay of vegetable substances, are returned to the soil, and are found in the ashes after the combustion of plants.

But with respect to that sulphur and phosphorus, which, as I have just stated, is found in vegetable albumen in combination with carbon, hydrogen, oxygen, and nitrogen, we are met by certain difficulties when we attempt to discover their origin. It seems the most obvious and natural explanation of the origin of this sulphur and phosphorus to suppose the sulphates and phosphates which are always present in the soil should be absorbed by plants, and become decomposed with evolution of oxygen, and should thus liberate sulphur and phosphorus, which then combine with the other elementary constituents, and form vegetable albumen. But to this supposition it may be objected that sulphates and phosphates are not very readily decomposable; and, moreover, another origin may be assigned to the sulphur and phosphorus of albumen, which will seem to be more probable, because it associates these with the other ultimate elements of that proximate vegetable constituent. They may be derived from two gaseous compounds, namely, sulphuretted hydrogen, and phosphuretted hydrogen, instead of from sulphuric acid and phosphoric acid. The hydrogen compounds of sulphur and phosphorus are very readily decomposed, they may, therefore, liberate their sulphur and phosphorus in plants, so as to admit the formation of vegetable albumen out of its immediate constituents.

It may be objected to this supposition, that the hydrogen compounds of sul-

phur and phosphorus have not hitherto been discovered to be an essential constituent either of the soil, water, or atmosphere; the force of this objection, however, will be lessened by the following remarks.

In the process of putrefaction of those proximate constituents of plants which contain sulphur and phosphorus, these elements are evolved in combination with hydrogen, as sulphuretted and phosphuretted hydrogen. Both these gases are soluble in water, miscible with atmospheric air, and capable of being absorbed by the roots of plants, and of being used in their nutrition. In a theoretical point of view there is nothing opposed to the supposition of their being thus employed. You may perhaps object that the peculiar odor of these gases,—sulphuretted hydrogen smelling like rotten eggs, and phosphuretted hydrogen like putrid fish,—would, were they present in the atmosphere, lead to their immediate detection. But you must remember we cannot detect ammonia by the smell, although invariably present, because it is so greatly diluted; the gases in question may likewise exist undetected, if extremely diluted. Again, you may say, these gases have not been discovered invariably in the atmosphere by chemical tests: truly; but neither has their presence been very diligently looked for, and our reägents may not be susceptible enough to detect such minute proportions as may exist. The exceedingly small amount of sulphuretted and phosphuretted hydrogen, which can be supposed to be thus insensibly present in the atmosphere, forms no objection to their being the source of the sulphur and the phosphorus of plants, since the amount of these elements in the constituents of plants not existing as sulphuric and phosphoric acids, is also exceedingly minute; indeed, their detection as constant elements has only recently been rendered practicable.

We are not, moreover, in this estimation, limited to the hydrogen compounds of sulphur and phosphorus which originate in the putrefaction of the organic substances containing these elements, but we must also consider that IN THE DECAY AND PUTREFACTION OF ORGANIC SUBSTANCES THE PHOSPHATES AND SULPHATES OF THE SOIL BECOME DECOMPOSED, so as to give rise to the formation of sulphuretted and phosphuretted hydrogen.

This consideration serves at the same time to obviate an objection drawn from the easy decomposition of the hydrogen compounds of sulphur and phosphorus, which, supposing them to be present in the atmosphere, would insure a constant diminution of their amount, until they would at length be wholly removed, and converted into phosphoric and sulphuric acids. As this process probably takes place continually, and as the portion of sulphur and phosphorus, which serves for the constituents of plants and animals, is, at their death, and through decay or putrefaction, again rendered back, it is more than probable that nature has made a provision in this circulation for a restitution of the phosphuretted hydrogen, and sulphuretted hydrogen, to the atmosphere. And this, I think, is certainly effected when organic substances, containing in themselves no sulphur or phosphorus, undergo putrefaction, in direct contact with inorganic matters containing sulphates and phosphates.

The direct proof, however, of the accuracy of our supposition of the origin of the sulphur and phosphorus of albumen from those gaseous compounds, must be left to subsequent investigations; we are certainly not able at present to offer you such a direct proof. The following, however, is one of many experiments which may assist to establish the truth of the opinion I have advanced, although it must be admitted to require confirmation. The seeds of certain plants, remarkable for the large amount of their proximate elements, containing sulphur, such as garden cress, &c., have been sown in an artificial soil, containing no material whatever of which sulphur is an element. The seeds germinated and grew; upon examining the plants for the amount of sulphur they contained, it was found to be considerably greater than the amount in the seeds when sown. One hundred grains of seed produced plants which yielded 15 times more sulphur than the seed from which they sprung. We are told that neither the soil in which these plants were grown, nor the water used for moistening them, contained any sulphates. The large amount of sulphur found in them could, therefore, have been derived from no other source than the atmosphere, although it is stated they were kept covered with a bell glass in a room, the air of which had no perceptible admixture of sulphurous gases. Since the atmosphere of the

room must have had access to the plants, it must also have contained sulphuretted hydrogen, although far too highly diluted to admit of detection either by the smell or by tests, and from this gas the plants must have derived their sulphur.

In conclusion, Gentlemen, let me repeat, I am far from considering this view of the origin of sulphur and phosphorus an established truth; but, nevertheless, I think it cannot be rejected without further and more careful experiments and observations.

LECTURE X.

THE ASHES OF PLANTS.

GENTLEMEN:—I have already, in a former lecture, had occasion to state to you that upon the combustion of any plant, or of any part of a plant, we invariably obtain a residuary substance, which is universally known as ASHES; and, further, that the ashes of plants consist of, or are formed from, such of their ultimate constituents as are derived only from the soil. I proposed, as you may recollect, to designate these the fixed, or earthy, elements of plants; and we may adopt this designation, since it refers immediately to their origin.

Now, in order to ascertain what are the substances present in the ashes of plants, a great number and variety have been burned during many years, and the ashes thus obtained submitted to chemical examination and analysis. As I have already told you, only a few of the elements known to chemists have at present been detected in the ashes of plants—namely: silicon, sulphur, phosphorus, chlorine, iodine, and bromine, (the two latter only in the ashes of marine plants,) potassium, sodium, calcium, magnesium, iron, and manganese.* Some authors add to these copper, but I have never been able to detect this metal in the ashes of plants.

But these elements are never found in the ashes of plants, or in living plants in their simple or uncombined state; on the contrary, we find them all, with the exception of iodine, chlorine, and bromine, invariably in chemical combination with oxygen; and, before we can see them in their elementary condition, they must be with great difficulty separated from oxygen. Nay, we do not even find them in so simple a form of combination as their oxygen compounds, which are either acids or bases, but we meet with both these forms of compounds, acids and bases, again united, giving rise to the formation of still more complex substances, denominated *salts*. It might be, in some respects, sufficient for me to make you acquainted with these salts only, and leave untouched their constitution. A deeper insight, however, into the elementary composition of salts will be of too great importance to you, from its practical bearings upon agriculture, to permit me to neglect making you acquainted with it, as I shall show you hereafter.

Chemists divide all elementary bodies into two classes—namely, *metals* and *metalloids*, or non-metallic substances.

The distinction between these two classes of bodies depends upon their relation to heat and electricity. If a substance opposes no resistance to a rapid diffusion of heat and electricity throughout its substance and over its surface, or, as the natural philosophers express it, is a good conductor of heat and electricity, it is called a *metal*. If it presents characters the opposite of this, it is called non-metallic, or a metalloid. This definition of a metal may appear strange to you, as probably you have hitherto thought a great specific gravity to be the characteristic of a metal. But it is not so, since we are acquainted with several metals specifically lighter than water.

The salts found in the ashes of plants are formed by the union of substances belonging to both these classes. Sulphur, phosphorus, chlorine, iodine, bromine and silicon, together with carbon, oxygen, hydrogen and nitrogen, belong to the class of *non-metallic* bodies; whilst the remaining elements—namely: potassium, sodium, calcium, magnesium, iron and manganese—are *metals*.

* To these must now be added Fluorine, vide page 49, note.

It is of great importance for you to know that the combinations of the non-metallic class of substances with oxygen or hydrogen generally form acids; and it is in this state of combination they are met with in the soil, as well as in plants and in their ashes. Thus, carbon and oxygen form *carbonic acid;* sulphur and oxygen, *sulphuric acid;* phosphorus and oxygen, *phosphoric acid;* chlorine and hydrogen, *hydrochloric acid;* silicon and oxygen, *silicic acid;* and nitrogen and oxygen, *nitric acid;* whilst, as an exception to this rule, nitrogen forms with hydrogen a base—namely, *ammonia.*

All these acids have a powerful tendency to combine with bases whenever they are brought into contact with them, and since bases are almost every where present upon the surface of the earth, in the soil, and invariably in the ashes of plants, it is not surprising that these acids and bases are very rarely found uncombined in the soil, and always in combination with each other in plants, and in the ashes of plants, in the form of salts. You must not, therefore, expect to detect the presence of sulphuric or phosphoric acid in a plant or in its ashes, even when they exist to a large amount, by an acid taste, since you know that this property of acids is lost when they are combined with bases, and becomes manifest again only after the decomposition of salts into *acids* and *bases.*

The presence of metals in the ashes of plants is a subject of great interest. Amongst these are those very metals, the specific gravity of which refutes the old definition of the term metal,—that is, "that metals are substances of great specific gravity." If you throw a piece of potassium or sodium wrapped up in tin-foil, upon the surface of water, you will see it swim like cork; a proof that these metals are specifically lighter than water, swimming even in the tin-foil (which itself is heavier) used to protect it from the action of the water.

Metals in general, and the metals contained in the ashes of plants especially, have a great tendency to combine chemically with oxygen, and form bases. This tendency, varying much in its degree in various metals, has given rise to a classification of metals into noble and base, or precious and common metals. By noble metals, we understand those which combine with difficulty with oxygen, and the oxygen compounds of which may be easily decomposed; whilst the reverse is the case with the base or ignoble metals. Thus gold and platinum, when exposed to the action of the atmospheric oxygen, retain their metallic lustre, whilst under the same circumstances, lead, iron, copper, &c., become tarnished, or lose their lustre, owing to the metal having combined with oxygen. The rusting of iron is a familiar example of the readiness with which certain metals combine with oxygen. Now, as all the metals occurring in the ashes of plants are of the latter class, or ignoble metals, it is quite natural that we should find them combined with oxygen, that is, in the state of bases; and again, as bases will always combine with acids, whenever they meet, we invariably find both in the state of salts, since at least one acid, viz., the carbonic, is always present. All the oxides of metals, occurring as constituents of plants, will combine with carbonic acid, forming carbonates.

A few explanatory remarks upon the nature and properties of the metals found in the ashes of plants will be interesting, and will serve to render the whole subject more intelligible.

Potassium is the lightest of all the metals; it swims on water, as I have mentioned before, even although enveloped in tin-foil. It has the greatest affinity for oxygen, that is, it combines most readily, and remains combined most firmly with oxygen,—in other words, potassium is the most combustible of the metals. A piece of potassium thrown upon water ignites and burns vividly. This arises from its great affinity for oxygen, which causes it to decompose the water, in order to unite with its oxygen, this action taking place so energetically as to cause ignition. By the ignition of the potassium, the liberated hydrogen is also kindled, and combining again with the oxygen of the atmosphere, again forms water. The newly-formed product of the chemical combination of potassium and oxygen, is an oxide of potassium; it is well known as *potass.* This dissolves in the water, imparting to it all the properties of an alkaline solution, as you will find by testing it with dahlia paper: and if you evaporate the solution, the alkali will be left in the form of a solid white substance. If this potass is left exposed to the atmosphere, it will combine with its carbonic acid, forming carbonate of potass, a substance well known in commerce, and extensively em-

ployed in manufactures and trades. Carbonate of potass, however, obtained by this process, would be a very costly substance; other methods are, therefore, resorted to, for its production on a large scale. All land plants when burned leave carbonate of potass in their ashes. The combustion of wood and other parts of plants is, therefore, employed, and, from the resulting ashes the carbonate of potass is washed out by means of water, of course contaminated with other soluble salts, and the solution being evaporated, in copper cauldrons, leaves a dry saline mass. From carbonate of potass so produced, potass may subsequently be produced by separating the carbonic acid; and pure metallic potassium by separating the oxygen of the potass. Potassium, in its metallic state, is quite soft and plastic, so that two pieces may be united together by the mere warmth of the hand; whilst two pieces of iron, as you know, require a strong red-heat to be welded together.

Potass exists in plants most frequently combined with vegetable acids, or with carbonic, sulphuric, or phosphoric acids, and very rarely with nitric acid. The combinations of potass with vegetable acids occurring in plants are, by the combustion or decay of the plants, converted into carbonate of potass. In the soil, potass is found principally as a carbonate, or as a soluble silicate, both originating from the decomposition of silicates containing potass.

The metal SODIUM has properties very analogous to potassium; it swims upon water, and combines with the oxygen of water, forming a soluble alkaline base, *oxide of sodium*, or, more commonly, "*soda*." Soda has the same affinity for carbonic acid as potass; a solution of soda exposed to the atmosphere is gradually converted into a solution of carbonate of soda, and by evaporating it, this salt may be obtained. Of course this is not the process employed for procuring carbonate of soda for commercial purposes. One method is to reduce marine plants, sea-weed, &c., to ashes by burning, and to extract the carbonate of soda from these ashes, by treating them with water. Pure metallic sodium may be obtained by first separating the carbonic acid from the carbonate, and then the oxygen from the soda.

Soda is very rarely contained in a living plant in combination with carbonic acid. The carbonate found in the ashes of plants after combustion, has been produced in the process from the salts of soda, with vegetable acids which previously existed in them. Soda moreover occurs in plants and in the ashes of plants, as hydrochlorate of soda, sulphate of soda, phosphate of soda, and silicate of soda. Soda salts occur in the soil only in very minute proportions (except the nitrate of soda, in some parts of America), and probably only as carbonate of soda and silicate of soda, both owing their origin to the decomposition of silicates. But in sea water, salts of soda are very abundant; it is not, therefore, very extraordinary that we should find these salts in the largest proportion in the ashes of marine plants.

CALCIUM, in its metallic state, has hitherto been produced only in very minute quantities, for scientific experiments. When thrown into water it combines with oxygen, liberating hydrogen. The thus newly-formed oxide of calcium dissolves in a large amount of water, forming a feebly alkaline solution, which, upon evaporation, leaves a white powder: this is *lime*. Like potass, lime absorbs carbonic acid from the atmosphere, and is converted into carbonate of lime, or common chalk. The lime, known as *quick lime*, is produced by depriving the native carbonate chalk of its carbonic acid, by burning.

Carbonate of lime occurs very frequently in the ashes of plants, although the lime may have existed in the living plant in combination with vegetable acids. We find in the ashes of plants phosphate of lime, sulphate of lime, hydrochlorate of lime, and nitrate of lime. We shall see hereafter how important these lime salts are to vegetation, especially the phosphate and sulphate. In the soil we find carbonate and sulphate of lime (gypsum) to a large amount, whilst the phosphate occurs only in comparatively very minute proportions. This admits of very ready explanation: the principal masses of mountains and rocks, and especially of aqueous rocks, consist of one or other of the former salts, that is, of carbonate of lime or of sulphate of lime, whilst phosphate of lime is only a very subordinate constituent in mountain or rocky masses; it constitutes the bulk only of certain rare species of minerals.

The bones of animals, more especially those of the mammalia, including man

contain more than half their weight of phosphate of lime. If you dissolve the phosphate of lime out of a piece of bone (the shoulder-blade of a sheep, for instance), you will find it loses considerably in weight, and you may bend it like a piece of leather.

PHOSPHORUS is obtained, for commercial purposes, exclusively from bones and urine (this animal secretion is exceedingly rich in phosphates); it being infinitely more easy and convenient to obtain the phosphorus from substances in which it has been concentrated by the powers of life in animal organisms, than to gather it laboriously from the ashes of plants or from the soil. Phosphoric acid is, as you know, a compound of phosphorus and oxygen.

MAGNESIUM bears the same analogy to calcium that sodium bears to potassium. Its oxygen compound, or oxide, is a white substance, sparingly soluble in water, and manifesting only a very feebly alkaline reaction. The oxide of magnesium, combined with the carbonic acid of the atmosphere, forms a carbonate, which is commonly known as *Magnesia*, or carbonate of magnesia. This salt is insoluble in pure water, but it dissolves in water containing carbonic acid in solution. The carbonic acid may be expelled by heat, leaving the pure oxide of magnesium, a substance well known as *calcined magnesia*, or *magnesia usta*, of the shops.

In the ashes of plants we find magnesia, chiefly in combination with phosphoric acid; and I shall have occasion hereafter to show you that the presence of this salt in considerable proportion is essential to the vigorous growth and development of a great many plants. In the soil, magnesia is most commonly found as a carbonate, although only to a small amount. In sea-water we meet with sulphate and hydrochlorate of magnesia. In the form of a carbonate, and in connection with carbonate of lime, magnesia takes a not inconsiderable share in the formation of mountains, in many parts of the earth. Minerals and rocky masses, consisting of carbonate of magnesia and carbonate of lime, are known as *dolomite, bitter spar*, or *magnesian limestone.*

Amongst the metallic constituents of the ashes of plants, I mentioned IRON and MANGANESE, because they may be invariably traced in them, although we know of no plant in which they are present to any large amount. These metals occur nowhere in nature in a pure, uncombined, or metallic state, and therefore certain chemical operations are required to separate them from the various combinations under which they are met with in nature. In the soil we invariably find them combined with oxygen, but only rarely as salts. This must be ascribed to the easy decomposibility of the carbonates and sulphates of iron and manganese, originally formed during the degradation of rocky masses.

Having thus, Gentlemen, glanced at the properties of the metals found in the ashes of plants, we will now return to the consideration of the *salts*, as contained in those ashes. And here we may first inquire, Whence do plants derive these salts? The answer to this question is obvious enough—they must draw them from the soil; and the presence of these substances in the soil is a well-established fact.

You may, perhaps, be disposed to consider this matter so obvious as to require no further explanation, and the more especially so, as the amount of these substances found in plants is extremely small. Indeed, there are certain plants, which, upon combustion, scarcely yield a thousandth-part of their weight in *ashes;* and, therefore, some persons have considered the earthy constituents of plants as merely accidental, and, therefore, unworthy of consideration.

I shall endeavor to show you, in my next lecture, that such an opinion is quite erroneous; and that, on the contrary, these substances are of the highest importance—in fact, that they are absolutely essential to the complete development of plants.

LECTURE XI.

ON THE ASHES OF PLANTS.—(CONTINUED.)

GENTLEMEN:—On the one hand, the circumstance that plants are capable of absorbing all the soluble materials present in the soil, and on the other hand, the known fact that all the constituents of the ashes of plants exist in the soil, and, under certain conditions, are soluble in water, has given rise to the notion that these substances, originally belonging to the soil and found in plants, ought to be considered as accidental constituents; and that we may very well suppose the development of plants would take place, even though none of these substances were present. I cannot dispute the truth of this inference as a general principle. The mere fact of ashes being left, after the combustion of plants, by no means conclusively proves that the substances found to compose the ashes are essential to the growth and development of plants; on the contrary, it proves no more than that such substances are present in a soluble state in the vicinity of growing plants, and are absorbed by them upon coming into contact with their roots.

We have, however, abundant and conclusive evidence to support the assertion that some of these substances, so far from being merely accidentally present in plants, are absolutely essential to the healthy and complete development of all plants. They are *necessary* constituents of vegetable substances.

The following experiments prove this view of the matter to be correct.

The seeds of various plants were sown at the same time in pure sand and in an artificial soil, prepared so as to resemble common arable soil.

The following were the results obtained:—

Name of the Plants.	Growth in Pure Sand.	Growth in Artificial Soil.
VICIA SATIVA—*Vetches.*	The plant on the 4th of July had reached a height of 10 inches, and the flower buds seemed inclined to expand one by one. On the 6th, a few flowers had expanded. On the 11th, they began to form the pods, which contained NO seeds, and had faded on the 15th. The lower leaves of all the plants had turned *yellow*.	The plant had reached, by the middle of June, a height of 18 inches, so as to require to be supported by sticks. It began to bloom luxuriantly on the 16th, and on the 26th to put forth a great many healthy pods, which arrived at maturity on the 8th of August, and contained *seed able to germinate.*
HORDEUM VULGARE—*Barley.*	The barley had up to the 30th of June, when it bloomed *imperfectly*, attained a height of nearly 15 inches; but it did *not* form any grain. In the month of July the spikes and husks became *yellow*.	On the 25th of June, the barley was in *perfect flower*, and 27 inches high. On the 10th of August it yielded *ripe and perfect* grains.
AVENA SATIVA—*Oats.*	On the 30th of June, the oats, very imperfectly flowering, was 18 inches high; but it did not produce perfect grains, and in the course of July became *yellow*.	The oats on the 28th of June, in *perfect bloom*, had attained a height of 30 inches, and on the 16th of August yielded *ripe* and *perfect* seed.
POLYGONUM FAGOPYRUM—*Buckwheat.*	This succeeded better than any of the other plants. It appeared above the soil on the 8th of May, and at the end of June had grown to 18 inches high, and branched considerably.—On the 28th of June it began to flower, and continued up to September, but *without* forming fruit. It would have continued to flower longer, but it was removed on September 4th, for investigation.	The buckwheat grew with great rapidity to 30 inches high, and branched so freely as to require support. It began on the 15th of June to flower, and formed perfect seeds, of which many, on the 12th of August, were *ripe*. On the 4th of September it was removed from the soil, still bearing flowers and unripe seeds.

Name of the Plants.	Growth in Pure Sand.	Growth in Artificial Soil.
NICOTIANA TABACUM—*Tobacco.*	Tobacco was sown on the 10th of May, and appeared above the sand on the 2d of June.—But it developed itself quite in a natural manner. When the plants had shot out the second pair of leaves, the superfluous plants were removed, only five of the more vigorous being allowed to grow. These grew very slowly till October, (when frost set in,) but did not produce more than four leaves, attained a height of only five inches, and formed no stem. They were removed Oct. 21.	Tobacco was sown on the 10th of May; it appeared above the soil on the 22d, and grew vigorously. When the plants had put forth the second pair of leaves, so many were removed as to leave only three of the most vigorous. These grew up well, produced stems above 3 feet high, with abundant foliage; began to flower on the 25th of July, and produce seed on the 10th of August, and yielded on the 8th of September several *ripe* capsules, with *perfect* seeds. The plants were removed from the soil on the 21st of October.
TRIFOLIUM PRATENSE—*Purp. Clover*	The clover appeared above the sand on the 5th of May, and at first grew pretty well, but up to the 15th of October had attained only 3½ inches in height, when its leaves began suddenly to turn brown. It was, therefore, removed.	On the 15th of October the clover had reached a height of 10 inches, and was dark green, full of leaves; when it was removed from the soil, in order to compare it with that grown in sand.

The reporter of these experiments remarks, that for the first eight or ten days, there was no perceptible difference in the growth of the plants, but from that time the plants growing in the artificial soil were developed more vigorously and rapidly; their stems and straws were stronger and firmer, and their leaves were of a darker green than was the case with those grown in the sand. During the whole process of vegetation, the plants were watered only with pure distilled water. A subsequent examination of the plants, for the amount of their ashes, showed the amount of ashes to be far more considerable in those grown in the soil than in those grown in the sand.

100 *parts of these vegetable substances dried at* 25° *to* 30° *C.*

	Parts of Ashes.		Parts of Ashes.
Of the Vetches grown in the sand	6.77	Buckwheat, grown in the sand	2.
Do. grown in the soil	12.22	Do. grown in the soil	4.
Barley, grown in the sand	5.38	Tobacco, grown in the sand	12.6
Do. grown in the soil	7.04	Do. grown in the soil	18.2
Oats, grown in the sand	4.56	Purple Clover, grown in the sand	6.78
Do. grown in the soil	5.73	Do. grown in the soil	11.6

All these plants received the same amount of carbonic acid, ammonia and water from the atmosphere, whilst the difference consisted in the amount of salts supplied to them by the sand and the soil respectively, and to this we must attribute the great difference observed in the growth and development of the plants. Although the sand is capable of yielding a small amount of soluble salts, which are produced in it by the decomposition of some of its parts by the carbonic acid of the atmosphere during the protracted experiment, these were, as we have seen, not sufficient to enable the plants to become sufficiently perfect to produce ripe and germinable seed.

Those experiments, therefore, prove the correctness of our assertion, namely, that the constituents of the soil, which we find again in the ashes, are essential to the perfect growth and development of plants.

Many observations prove the necessity of the absorption of these substances by plants. Thus, if we plant certain flowers, such as balsams, leucojums, &c., in soil contained in glazed flower pots, and supply only their leaves with water, taking care that none runs down their stems or reaches the soil; as soon as the soil becomes completely dry, the leaves will begin to grow yellow and fade. By moistening them freely and frequently for some time, they may be partially restored, but in no case could I keep the plants alive beyond the sixth day from the first fading of the leaves. Here there is no deficiency of carbonic acid, ammonia or water, but from want of water in the soil, the plants cannot absorb the saline matters present in the soil, and therefore perish. Practical gardeners have informed us that "during the summer of 1842 we discovered that incessant labor may in some measure supply the want of rain. The soil of our tree plantations, in consequence of the long continued and excessive drought, cracked and split in every direction, and the trees began to fade and wither. In order to prevent this we loosened the earth around some of them, and filled up these fissures, and immediately the trees began to revive. This encouraged us to pro-

ceed; and we found that by turning up the soil and loosening it, we obtained an effect similar to that of a warm shower; we observed, in fact, that the soil thus labored attracts moisture from the atmosphere. As soon as the soil hardened again the leaves became wrinkled and covered with mildew."

I think the phenomenon thus described is explained best by supposing it to arise from the dry salts of the soil being rendered capable of absorption by plants by the moisture attracted from the atmosphere, and it affords, in my opinion, another and a decisive proof of the necessity for the presence of these salts in the soil.

If from the vicinity of plants we withdraw the necessary salts, they will not continue to exist, and far less will they perfect their growth and arrive at maturity.

If it be objected to this, that seeds sown in soil altogether destitute of salts, have germinated and produced plants, wretched abortions indeed, and utterly incapable of bringing forth new seeds, yet, nevertheless, vegetating for some time, producing straw, stems and leaves; and again, that hyacinths grow luxuriantly in pure water, nothing else being present except the constituents of the atmosphere. It may be inferred from this latter example that the saline constituents of the soil are not of equal importance to all plants. Yet, nevertheless, these objections may be easily refuted.

In the first place, we may remark that the saline constituents of the soil, necessary to the growth and perfection of plants, may invariably be detected, to a certain amount, in their seeds. Thus, a kind of reservoir is provided, whence plants receive the necessary salts, until the root is sufficiently perfect to derive them from the soil. It is at the expense of these salts contained in the seeds that plants, placed in soils deficient in saline matters, are able to produce a few scanty leaves and feeble stems or straw. This resource is, however, soon exhausted, and the growth of the plant soon begins to flag, even when there is abundance of the other elements of nourishment present, and, finally, the plant dies without having reached its full development. If we examine such plants for the amount of ashes contained in them, it will be found to be no more than was contained originally in the seeds whence they sprung, and hence their saline constituents are insufficient for their perfect growth. In like manner, the hyacinth bulb contains a certain amount of saline matters sufficient for the perfect development of the plant, even when the water in which they grow afford no salts. But in the second year, this store of saline constituents being exhausted, the bulb is only capable in very rare instances, of producing more than the mere abortion of a plant; it usually dies even at that early period. Hence the necessity of placing bulbs which had once produced a plant into a soil whence they may again derive a new supply of the necessary salts, to enable them to produce new plants. This, at least, is my view of the matter.

These experiments and observations are supported by many other proofs of the absolute necessity for the saline constituents of the soil to the life of many vegetables; but as these are of a more recondite nature, and as it would lead us into discussions too extensive for our present purpose to give a satisfactory account of them, the above may suffice; and we will now proceed to examine in what proportions these saline constituents actually exist in various plants.

In this respect there is a great diversity, not only between plants of different species, but also between the various parts of one and the same plant, as the following table exhibits:—

According to Boussingault—

	Of Ashes.		Of Ashes
100 parts of the Grain of Wheat contained	2·4	100 parts of Potatoes	4·0
" " Rye	2·3	" Beet-root	6.3
" " Oats	4·0	" Swedish Turnips	7·6
" Wheat-straw	7·0	" Dried Peas	3·1
" Rye-straw	3·6	" Pea-straw	11·3
" Oat-straw	5·1	" Clover	7·7

All these substances had been dried at 110° C. (= 230° Fahrenheit) previous to combustion.

According to Weigman and Polstorff—

	Ashes.		Ashes.
100 parts of the Seeds of Vetches contained	2·56	100 parts of the Seed of Buckwheat	1·52
" " Grain of Barley	2·43	" " Clover Seed	4·68
" " " Oats	2·86		

(I do not know whether these substances had been dried at the common temperature of the air, or at a higher temperature.)

According to De Saussure—

	Ashes.		Ashes.
100 parts of Oak leaves contained	5.5	100 parts of Hazel wood	0·5
" " wood	0.2	" " bark	6·2
" " bark	6·0	" White Beech wood	0·6
" Poplar leaves	9·3	" " " bark	13·4
" " wood	0·8	" Fir Tree leaves	6·28
" " bark	7·2	" " wood	0.38
" Hazel leaves	7·0	" " bark	1·78

These substances were only dried in the open air.

According to Braconnot—

100 parts of the following *Jointed Ferns*, or *Shave Grasses*, in a dried state, yielded :—

	Ashes.		Ashes.
Equisetum Fluviatile	23·6	Equisetum Arvense	13·8
" Hyemale	11·8	" Limosum	15·5

Nay, further, one and the same part of a plant yields a different amount of ashes, according to the state of its growth at the time of investigation, as may be seen in the following table, compiled from experiments made by De Saussure:—

	Ashes.
100 parts of Oak leaves, gathered on the 10th of May, contained	5·3
" " " 27th of September	5·5
" Poplar leaves " 26th of May	6·6
" " " 12th of September	9·3
" Hazel leaves " 1st of May	6·1
" " " 2nd of June	6·2
" " " 20th of September	7·0
" Horse Chesnut leaves, 10th of May	7·2
" " " 23rd of July	8·4
" " " 27th of September	8·6
" Sun Flower, (Helianthus Annuus,) gath'd. prev's. to flow'ng., 25th of June	14·7
" " " " 23d of July	13·7
" " " " with seeds, 25th of September	9·3
" Wheat, a month before flowering	7·9
" " in flower	5·4
" " with ripe grain	3·3
" Indian Corn, (Maize,) a month before flowering	12·2
" " in flower	8·1
" " with ripe seeds	4·6

Having thus explained to you, and I trust proved to your satisfaction—*first*, that the earthy constituents of plants are indispensable for their complete development; and, *secondly*, that different plants and various parts of one and the same plant require different proportions of these constituents; we will proceed to inquire, *thirdly*, whether the same saline and earthy matters are required by every plant, or whether some plants require some, and others different salts, for their perfect growth; and this is a question not less interesting and important than the former two.

You will at once perceive that the investigation and determination of this last question must be of the greatest possible practical importance. Because if, upon burning a perfectly ripe plant with its seeds, sulphate of potass alone is found in its ashes, it would of course only be necessary that sulphate of potass should be present in the soil where you wish that plant to grow. In like manner, if, upon combustion, the ashes of plants contained carbonate of lime, such plants will not grow upon a soil destitute of lime.

Now, with respect to the first part of the inquiry we now propose to enter upon, namely, whether every cultivated plant requires *all* the constituents of the soil for its perfect growth? In my opinion, this must be answered in the affirmative, with the exception of two of the elements belonging to this class, namely, bromine and iodine, as these seem confined to marine plants. I, however, confess I cannot bring forward facts absolutely proving the opinion I have advanced, and I well-know many objections may be made to that opinion. The analysis of ashes by a great many chemists may be adduced against it. For example, in many examinations, soda, in others, magnesia, has not been found; and hence it has been concluded, that these substances were not present in the ashes of the plants examined. But if we take into consideration—first, that the amount of ashes left upon the incineration of a plant is not great; secondly, that the detection of the substances I have just mentioned is attended with some difficulty; thirdly,

that it is very easy to mistake and confound these substances with others; and, fourthly, that in the examinations hitherto made of the ashes of land plants, the experimenters have proceeded upon certain theoretical views, or for certain purposes, which rendered it indifferent whether soda was discriminated from potass or not. I think, if these circumstances be duly considered, you will agree with me, that the *non-detection* of soda in certain plants does not prove that it may not exist in those plants. And even when ashes are directly tested for soda, the minute amount present, and the difficulty of detecting its presence, may easily cause it to be overlooked. However, I repeat, it is, after all, only my opinion, that this element, and others which are sometimes not detected, are invariably present; and we must wait for repeated and very accurate analyses of ashes of many plants, before we can decide that any of the saline constituents are not necessary for any given species of plants.

This uncertainty, gentlemen, must be admitted to be an inconvenience and drawback against the value of our conclusions; but it is fully and abundantly counterbalanced by the *certainty* we possess with respect to some other saline constituents, of which we know that they are present in all and every kind of plant, and by the circumstance that we know with certainty that certain plants require a larger proportion of the earthy or saline constituents than others, and *vice versâ*.

With respect to the first point, we know that potass, lime, phosphoric acid, sulphuric acid, and silicic acid, are never absent from any plant—at least, from any of the cultivated plants; but on the contrary, the growth and development of these plants is indissolubly linked with the presence of these substances in the soil, and these are therefore invariably found in the ashes of all cultivated plants.

The examination of the ashes of various plants proves, that the saline constituents are present in various proportions, so that in one plant, or part of a plant, one or other of these salts is found in a preponderating proportion, whilst in another plant or part of a plant we find another of these constituents preponderate. Now, upon examining the ashes of the same plant grown in different soils we invariably find the same relative proportions of saline constituents in those ashes, whether obtained from the whole plant or its several parts. We may, therefore, safely conclude that these relative proportions are fixed; and it is further evident that the differences in the amount of salts contained in various ashes, forms distinctive marks of the different species of plants, and, consequently, is an essential condition of their existence.

The following Table will enable you to judge of the correctness of this conclusion;

100 *Parts of Ashes obtained by the incineration of the Grain of the following Plants contained:*

	Of Red (Winter) Wheat. (FRESENIUS.)	(Of White (Summer) Wheat. (WILL.)	Of Rye. (FRESENIUS.)	Of Peas. (WILL.)	Common Field Beans. (BUCHNER.)
Phosphate of Potass	36·51	52·98	52·91	52·78	68·59
Phosphate of Soda	32·13	0·00	9·27	5·67	
Phosphate of Lime	3·35	5·06	5·21	10·77	9·35
Phosphate of Magnesia	19·61	32·96	26·91	13·78	19·11
Phosphate of Iron	3·04	0·67	1·88	2·46	....
Sulphate of Potass	traces.	traces.	2·98	9·09	1·84
Chloride of Sodium, or Common Salt	....	....	....	3·96	....
Silicate of Potass	....	....	0·34	....	1·11
Silica	0·15	3·30	....	....	....
Carbon (Charcoal) owing to imperfect combustion). Sand (accidentally mixed with the ashes)	4·99	8·03	0·50	....	....

100 *Parts of the Ashes of good Meadow Hay contained:—*

Silica	60·1	Sulphate of Potass	2·2
Phosphate of Lime	16·1	Chloride of Potassium	1·3
Perphosphate of Iron	5·0	Carbonate of Soda	1·1
Lime	2·7	Carbonate of Lime	0·9
Magnesia	8·6	Loss	0·8
Sulphate of Lime	1·2		

100 *Parts of the Ashes of Rye Straw contained, according to Fresenius* :—

Potass (combined with Silicic Acid)	16·09	Phosphate of Magnesia	1·28
Sulphate of Potass	1·75	Perphosphate of Iron	3·20
Chloride of Potassium	0·25	Protophosphate of Magnesia	traces.
Common Salt	0·56	Silica	63·89
Lime (combined with Silicic Acid)	7·62	Carbon (Charcoal) (owing to imperfect combustion)	0·94
Magnesia (combined with Silicic Acid)	1·92		
Phosphate of Lime	2·50		

More recently, Drs. Will and Fresenius have published the following :—

Actual results of the analyses of 100 *parts of the ashes of*

	Wheat.		Rye.		Peas.	Apple-tree.		
	Grains. Red.	White.	Grain.	Straw.		Wood.	Misle-toe.	Lichen
Potass	20·80	30·17	31.89	17·03	39·25	13·67	35·32	10·07 (Potass and Soda)
Soda	15·01	....	4·33	....	3·96	0·32	....	
Lime	1·83	2·76	2·84	8·98	5·87	45·19	19·40	10·38
Magnesia	9·12	12·08	9·86	2·39	6·41	5·30	9·59	5·33
Peroxide of iron	1·29	0·28	0·80	1·35	1·04	....	....	....
Phosphate of peroxide of iron	....	....	....	....	....	1·71	1·83	14·56
Phosphoric acid	46·91	43·89	46·03	3·80	34·29	2·95	16·56	....
Chloride of sodium	....	....	trace.	0·56	3·69	0·32	1·02	....
Chloride of potassium	....	....	....	0·25	....	....	....	....
Sulphuric acid	....	....	1·42	0·81	4·89	0·66	1·41	....
Silica	0·15	....	0·17	63·89	....	0·93	1·62	....
Carbonic acid	....	....	....	....	....	24·18	13·09	4·64
Charcoal and sand	4·89	9·03	2·66	0·94	1·38	2·03	0·54	49·73
	100·00	98·21	100·00	100·00	100·78	97·26	100·38	***

*** The remaining constituents were not estimated.

Per-centage composition, after deducting the carbonic acid, the charcoal, and the sand.

	Wheat.		Rye.		Peas.	Apple-tree.		
	Grains. Red.	White.	Grain.	Straw.		Wood.	Misle-toe.	Lichen
Potass	21·87	33.84	32·76	17·19	39·51	19·24	40·71	......
Soda	15·75	....	4·45	....	3·98	0·45	....	......
Lime	1·93	3·09	2·92	9·06	5·91	63·60	22·37	......
Magnesia	9·60	13·54	10·13	2·41	6·43	7·46	11·06	......
Peroxide of iron	1·36	0·31	0·82	1·36	1 05	....	....	......
Phosphate of peroxide of iron	....	....	....	....	....	2·41	2·11	......
Phosphoric acid	49·32	49·21	47·29	3·82	34·50	4·15	19·09	......
Chloride of sodium	....	....	....	0·57	3·71	0·45	1·17	......
Chloride of potassium	....	....	....	0·26	....	....	....	......
Sulphuric acid	0·17	....	1·46	0·83	4·91	0·93	1·62	......
Silica	....	....	0·17	64·50	....	1·31	1·87	......
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	......
Oxygen in the bases of the phosphates.	12·35	11·92	11·97	....	11·13	....	....	......

The foregoing Tables demonstrate to us the general principle we have been speaking of. Compare the amount of silica and the silicates in the ashes of rye-straw with that in the ashes of the grains, and you will find, in the former nearly 90 per cent., whilst in the latter there is scarcely one-half per cent. of silica or silicates. And, then, on the other hand, look at the large amount of the phosphates in the ashes of grain, 96 per cent., whilst in the straw ashes there is scarcely 7 per cent.

The same difference exists between the grains of wheat and wheat-straw, De Saussure's experiments show us that the ashes of wheat-straw contains about 70 per cent. of silicate of potass, and only about 11 per cent. of phosphates. In the ashes of grains of wheat he found not quite 1 per cent. of silicates, and more than 76 per cent. of phosphates.

It seems to follow from all known experiments that the seeds of plants generally require a proportionally large amount of phosphates, as we invariably find them present in the ashes of seeds and grains to a far greater amount than in other parts of plants.

Besides the above examples of wheat and rye, investigations have been made, to ascertain the relative proportions of various salts in the ashes of many other plants; of these I may mention the following as worthy of your attention—the ashes of bean-stalks were found to contain 6 per cent. of phosphates; the ashes

of the beans contained 90 per cent. of phosphates. The ashes of the stems of Indian corn (maize) contained 15 per cent. of phosphates, those of the grain 83 per cent. of these salts. The ashes of the wood of the horse-chesnut tree contained about 2 per cent. of phosphates, the ashes of the ripe chesnuts 40 per cent.

Having thus, as I believe, successfully proved to you, 1st, that the earthy or saline constituents of plants are indispensable to their growth and development; 2d, that different plants require different proportionate amounts of these constituents; and, 3d, that the composition of the ashes of plants depends upon the species of plants examined; I feel convinced that you will not look upon these substances with indifference. For although they certainly perform a subordinate part, relatively to the whole mass of the plant, yet you will now understand that a classification of plants, especially those which are cultivated, based upon the predominant constituents of their ashes, must be of considerable importance in practical agriculture. A careful consideration of what are the essential parts of the ashes of any given plant, will enable us to determine what constituents the soil must be able to furnish to that plant; and we can understand that a plant will fail on a soil, if it be wholly deficient in the saline materials, or does not contain them in that proportion or to that amount which is essential to its healthy growth and complete development.

Thus, if we divide the cultivated plants according to the constituent predominant in their ashes; for instance, into *potass* plants, *lime* plants, &c., this classification would at once indicate potass to be essential to the healthy growth of the former, lime to that of the latter class. And care would hence be taken to supply these materials to the soil in the proper proportion. Now this is precisely the main object of manuring, as I shall hereafter more fully prove to you.

The following attempt at such a classification of cultivated plants is from Liebig's "Agricultural chemistry":—

		Salts of Potass and Soda.	Salts of Magnesia and Lime.	Silica.
Silica Plants.	Oat Straw, with Seeds	34.00	4.00	62.00
	Wheat Straw	22.50	7.20	61.50
	Barley Straw, with Seeds	19.00	25.70	55.30
	Rye Straw	18.65	16.52	63.89
	Good Hay	6.00	34.00	60.00
Lime Plants.	Tobacco, (Havana)	24,34	67.44	8.30
	" (Dutch)	23.07	62.23	15.25
	" (grown in artificial soil)	29.00	59.00	12.00
	Pea Straw	27.82	63.74	7.81
	Potato-herb	4.20	59.40	63.40
	Meadow Clover	39.20	56.00	4.90
Potass Plants.	Maize Straw	72.45	6.50	18.00
	Turnips	81.60	18.40	....
	Beet Root	88.00	12.00	....
	Potatoes (tubers)	85.81	14.19	....
	Helianthus tuberosus*	84.30	15.70	....

I shall not at present, Gentlemen, proceed to draw any inferences from these facts; my object is simply to make you acquainted with them, because I am convinced that this knowledge will greatly facilitate our progress in the last section of these Lectures, when we shall have to treat of the practice of agriculture.

But, before I conclude this Lecture, let me impress upon your minds, that the deficiencies and weak points of the subjects we have been occupied in discussing, arise solely from the circumstance that agriculture has only very recently been submitted to scientific investigation; and there can be no doubt, therefore, that in the course of a few years our knowledge upon all these points will be far more perfect and positive.

* Jerusalem Artichoke.

LECTURE XII.

FALLOW.

General Introduction to the Practical Section of the Course....The Nature, Uses and Effects of Fallow.

GENTLEMEN:—In whatever manner you may picture to yourselves the first practice of Agriculture, when the human race was still in its infancy, you will, I think, agree with me in considering so much certain, that Agriculture originated in a desire on the part of man to have those plants which experience had taught him were useful to him, collected in his own immediate neighborhood, instead of being obliged to gather them from a distance.

It was a natural consequence of this desire that man should attempt to remove from their original site, and plant in his own vicinity, those plants, the usefulness of which had attracted his attention, and excited his desire of possessing. And it is, moreover, probable, that such attempts were not always successful; nay, it is certain that many of them must, at first, have miscarried, and that men were taught gradually and by experience, which plants will bear transplanting and which will not. Thus the term *cultivated* plants became established and defined; in its more extended sense this term means, such plants as, from their usefulness to mankind, become the subjects of care and labor to insure their growth, and which may be transferred from one locality to another without their complete developement being prevented.

Men could not, however, fail to observe very soon that the artificial cultivation of plants causes them to undergo considerable alterations in their nature and qualities; that the whole aspect of the cultivated plants differs from that of the wild plants; and that simultaneously with a change in the aspect, an alteration also ensues in those properties which render them useful, so that in one plant they increase while in another they decrease by cultivation. It was, therefore, natural that the causes of these changes should be sought for, and that cultivation should be confined to those plants, the usefulness of which is augmented by their being cultivated. Of course men arrived at this knowledge by experience, and learned what plants admitted of cultivation, and, therefore, which to prefer for this purpose. The term cultivated plant, then, in its more restricted sense, is applied only to the latter kind of plants

When, therefore, I define a cultivated plant to be one admitting of being transferred, without losing the useful properties it possessed in a wild state, or one the useful properties of which may be increased and improved by cultivation, I do not apprehend you will object to my definition, nor do I suppose you will make any objection when I further state, that all cultivated plants are in an abnormal, that is, in an unnatural and artificial state, to maintain which requires constant attention, and it is precisely this constant attention which forms the essential labor of cultivation. "The purpose of cultivation," says a modern writer, "is an abnormal (unnatural) development and production of certain plants or parts of plants, or of certain vegetable substances, applicable to the nutrition of man and animals, and to commercial purposes."

Cultivation has a constant tendency to oppose the peculiar development of plants ordained by nature, since it constantly endeavors to maintain their artificial or abnormal state.

Should you find any difficulty in admitting these definitions of cultivation and cultivated plants, let me refer you to your own experience. You all know well that cultivated plants, left entirely to themselves, return to their wild, that is, their natural state, or disappear altogether from the place where they grew, as soon as your efforts at cultivation cease; and you cannot fail to have remarked the great difference between plants in their wild and their cultivated state. The reason why we may apply the term *natural* to the wild plants, and abnormal or unnatural to plants under the influence of cultivation, may be illustrated by a reference to cattle-breeding, which is in this respect exactly parallel with agriculture. You have often seen cattle with such an enormous accumulation of fat

in their bodies, that they can scarcely perform their natural functions; their legs are hardly able to support them. The breeder, of course, boasts of this prodigy of fatness, because it was his intention, from the beginning, to produce it; but he would not assert that this was the natural state of the animal, or that Nature, if left to herself, would produce such an artificial state.

If, after these preliminary remarks, we now inquire for the cause of the differences existing between plants in a wild and in a cultivated state, we are at once led to the inequality in the nutritive matters necessary for the subsistence of plants. Assuming that wild and cultivated plants enjoy the same amount of moisture, light and heat, that is, a perfect equality in the general conditions of vegetable life, and knowing that the atmospheric conditions are the same for the cultivated as for the uncultivated plants, we have to look only to the soil for the cause of these differences.

For the purposes of cultivation, then, a knowledge of the constituents of the soil generally, on the one hand, and of the especial constituents indispensable to the various kinds of cultivated plants on the other hand, are the necessary preliminary acquisitions to enable us to lay a rational foundation for agriculture as a science. It is, therefore, very easy to explain why it is only of late years that Agriculture has been raised to the rank of a science, since Chemistry itself, which must necessarily precede it, has but very recently become a science. It was only after the various substances surrounding plants—atmospheric air, water, and soil—had been chemically investigated, and after the material wants of vegetables had been ascertained by careful and minute examinations, that the construction of an agricultural science could be reasonably thought of; all attempts at such an attainment, previous to the aid of a true chemistry necessarily miscarried.

If you ask me how it could happen that Agriculture could be practised for thousands of years, and successfully, too, without a scientific basis, or if you have formed the opinion that it may become a science without the aid of Chemistry, I would answer and refute such objections by remarking that Agriculture is an art as well as a science, and that the most skilful practice of an art, even from the earliest age to the present time, by no means implies that it must have a scientific basis. Innumerable experiments have been made, and, from an accumulation of experience, rules have been formed which it was necessary to follow, in order to practice the art of Agriculture successfully; these rules have been brought under certain more general points of view, and in such principles and laws we trace the first attempts to establish a science of Agriculture. But the many errors derived from false experience, and the fallacious inferences drawn even from correct observations, have always made the *theory* thus constructed disagree with and even contradictory to the practice of the art. So that neither has the theory been confirmed by the practice, nor has the practical art derived any real advantage from the theory. No better proof can be needed than this, that until very recently no real science of Agriculture has existed.

But it is now universally felt that the time has at length arrived when the mere empirical practice of the art of Agriculture is no longer sufficient. Agriculture, as an art, has probably reached its highest limits; the ingenuity of man has been exercised to the utmost in the mechanical labors of the soil, and in the treatment of cultivated plants, and it is altogether hopeless to expect any further improvements or inventions calculated to accomplish any great benefits in that direction. Nothing, in fact, remains to be done in this way. All the efforts, indeed, made at present to improve the practice of Agriculture, are directed, consciously or unconsciously, to the establishment of a *science;* and this can be accomplished only by a comprehensive study of the natural sciences, and especially of Chemistry.

The cultivators of the soil discovered the advantages of fallow, of the rotation of crops, and the necessity of manuring in an empirical way, that is, by experience; but, notwithstanding these points have been known for thousands of years, yet the Agriculturist, up to the present moment, is obliged to act just the same as was done at the beginning, in spite of the existence of many universally acknowledged defects in practice. People either have not dared to abandon the old methods, whilst yet they have not been able to improve them, or their attempts to introduce improvements, being only based upon empirical experience,

have failed; and the sacrifice of time, labor and capital have caused all deviations from the old beaten paths of practice to be looked upon with distrust.—Agriculturists have come to regard it as a matter of course—as an established rule—that a farm conducted on theoretical principles will yield less produce than it would in the hands of a purely practical farmer.

In short, defects in practice are obvious enough, upon many points, and yet theory has hitherto offered no assistance, because it has not been based upon correct principles. The art of Agriculture invented fallow, the rotation of crops, and manuring, but a true agricultural science can alone bring them to perfection.

This science may be subjected to two tests as to its truth or fallacy; first, it must not contradict well established experience; and secondly, when practically applied, it must yield more favorable results than mere empiricism.

I shall now endeavor to give you a condensed outline of the efforts recently made to found an agricultural science. I trust you will receive this attempt the more favorably, since, in the course of the preceding lectures, you have obtained a sufficient knowledge of those theoretical points necessary to enable you to judge whether this attempted agricultural science is really in accordance and harmony with the other sciences; and since, on the other hand, you possess practical experience respecting many points upon which the theory I shall place before you is based, and you will therefore be able to judge of its correctness.

Of course, we treat here only of the chemical department of the science.

I shall, as is usual, distribute this subject under three heads—FALLOW, ROTATION OF CROPS, and MANURING—which will permit me to introduce every thing relating to the new science of Agriculture, and to contrast it with the old theory.

FALLOW.

IN a work on Agricultural Chemistry, published about twenty years ago, the following remark occurs:—"The custom of allowing fields to rest after the production of several crops is very ancient, and forms, even to this day, the basis of the agricultural system followed in the greater part of Europe. When the ground has been exhausted by two or three consecutive crops, it is deemed necessary to allow it to rest, or *lie fallow*, for one or two years, in order to give it time to regain its productive powers."

Now, to enable us to decide on the much disputed point—the necessity of fallow—and fully to understand the meaning of the term *fallow*, it is indispensable that we should ascertain, *first*, the cause or causes of the diminishing productiveness of cultivated soil, and, secondly, what constitutes the so-called rest of the land.

I have explained in a former lecture that the chief part of the mass of ordinary soil contributes nothing towards the nutrition of plants, and that the necessity of the soil to cultivated plants consists in the mechanical support it affords them, and in its constituting a medium for transmitting the salts and the water essential to their growth and development.

Bearing this in mind, it is obvious that the soil may become unfitted for the advantageous growth of plants in two ways. 1st. It may be deficient in the proper mechanical condition for affording them a due support; or, 2nd. It may not possess the salts indispensable to the full development of plants. In both cases it requires preparation and amelioration before it can grow plants to any advantage.

We may readily conceive a soil, formerly extremely fertile, losing its fertility either from assuming an unfavorable mechanical condition, or from its store of salts becoming exhausted by successive crops. In either case, its productive powers are weakened or annihilated; and, if we wish to restore such a soil to fertility, we must attend to both its mechanical and chemical constitution.

Now, with respect to FALLOW, this has been called the *rest* of the fields; and this application of the term rest has given origin to most strange opinions upon the subject, which tend to obscure the matter and to prevent a right understanding of its true meaning and uses. A recent writer on Agriculture observes:—"The desire for and necessity of rest, which Nature has implanted in all animals when exhausted by long continued labor, has, no doubt, contributed much to the adoption of the practice of allowing the land to lie fallow. And, although the

parallel thus drawn between the functions of animal life and inorganic matter is neither correct nor logical, yet it has operated to establish the theory of fallow."

The earth cannot *sleep*, nor are we warranted to assume that it could be agreeable or beneficial to it to be spared for a time the infliction of the plough; but the soil in most cases has the property of altering its state of aggregation, when left without ploughing, and of accumulating a large amount of the salts indispensable to the growth of plants, if left for a time without cultivation.

With respect to the first point, it is evident that the continual digging, ploughing, hoeing, &c. may so break up and destroy the natural cohesion of the soil as to render it unfit for the support of plants, and therefore vegetation languishes on it, and the harvest fails, although all other conditions of a successful cultivation are fulfilled. If such soil be left to itself for some time, it gradually attains the due degree of aggregation, by the influence of moisture and by the cohesive properties of certain substances which, imbibing water, unite the disconnected particles of the soil, and thus restore its cohesion and fertility. This aggregation of loose particles of earth, as a simple result of time and the influence of rain, &c., is universally known, and it is made use of in many operations, as, for instance, in the construction of railways, &c.; what is called *settling* is the result of this process. The due mechanical condition of the soil I am speaking of may, as you know, be promoted by certain operations, such as ploughing, rolling, &c., and the question of the propriety of their employment is simply one of cost.

With respect to the second point, viz. the property possessed by the soil of accumulating, during fallow, the salts necessary for plants, let me remind you of what I said in a former lecture upon the subject of *degradation*. I explained to you the origin of the soil, in the disintegration of masses of rocks and minerals, and I stated that the process of decomposition, by which those masses were reduced into a material, fitted by its solubility and other properties for sustaining the life of plants, proceeds continually upon the smallest as well as the largest disintegrated particles. In all arable soil, amongst the mineral matters which constitute the great mass, there invariably exist portions still undergoing the same processes of disintegration and decomposition. The formation of certain alkaline salts and of soluble silica are the most important circumstances in these processes, in relation to the growth of plants; and we must, in the very first place, look to the production of these substances, in attempting to explain how it happens that a soil, having become sterile with respect to some plant or other, may, by merely lying fallow, become capable of again growing the same plant.

If the fertility of the soil depends—other circumstances being favorable—upon its containing a certain amount of alkaline salts and soluble silica, formed by the decomposition of minerals, it may easily be understood, that a certain amount of these substances being removed from the soil in the crops, the quantity originally in the soil may be greatly diminished. If the minerals still present in the soil become decomposed so rapidly that the formation of alkaline salts and soluble silica keeps pace with the withdrawal of these substances in the crops, such a soil will always remain fertile. This occurs very rarely, and scarcely in any soil in Europe. But if the annual removal of these substances exceeds the annual production, by degradation and decomposition, decreased fertility, and, at length, complete exhaustion of the soil, must of necessity ensue. This takes place the more rapidly, the greater the difference annually between the consumption and production—that is, the greater the amount of crops containing these substances, compared with the smaller quantities of salt produced in the soil by decomposition. This exhaustion of the soil, generally speaking, occurs all over Europe; under such circumstances, it is necessary to remedy the defect, either by the direct way of furnishing an artificial supply of the necessary salts, or by allowing the fields to remain uncultivated for a time, so as to permit the natural processes of degradation and decomposition to replace the necessary amount of soluble matters, and thus to restore the fertility of the soil. We shall treat of the artificial supply of saline matters, under the head of manuring. The substances which are required and supplied in the natural way, by fallow, are those which form the ashes of the cultivated plants.

You now perceive that the *rest* of the land, or fallow, bears not the slightest resemblance to the repose of a wearied animal. A correct explanation of the nature of a fallow is absolutely necessary, in order to enable us to form a just

opinion of its necessity or utility for certain fields or tracts of land; and this knowledge of its real use and meaning, moreover, enables us to ascertain what are the means required to shorten this period of non-cultivation, or to avoid it altogether. Thus, if we are assured that the benefit derived from fallow depends upon the progress made in the decomposition of substances in the soil, and consequent liberation of alkalies and soluble silica, it is evident that we may shorten this period, if we can by any means accelerate the progress of degradation, and we have, in the first place, to seek for such means. Now as we have already learned in a former Lecture that the decompositions giving rise to the formation of those soluble constituents of the soil are effected by the action of the atmospheric elements; and as we know from experience furnished by chemists, that all chemical action proceeds the more rapidly, the larger the surface which the substance acted upon offers, we learn at once in what manner repeated ploughing may shorten the period of fallow. The loosening of the soil by ploughing is not, as is generally supposed, beneficial as a mere mechanical means of fitting the soil for the growth of plants, but it extends the surface of the constituents of the soil, and by division and comminution of the masses it affords an easier access of the atmospheric elements, and thus facilitates degradation and decomposition. The same effect may be produced, and the period of fallow consequently abridged, by the application of lime, as is much practised in many parts of England, where its beneficial effect upon stiff clayey soils, applied during the moist winter months, is well known.

Besides the favorable action which lime must exercise upon such cultivated plants as require lime salts amongst their saline constituents—and to which we have applied the term *lime plants*, together with certain other effects more appropriately to be treated of under the head of manuring—I must mention that lime possesses the property of decomposing the silicates of the soil, and thus assists in the production of those soluble saline constituents which are indispensable to vegetable life, and abridges the period necessary for the land to lie fallow. For a full exposition of this point I must refer you to Professor Liebig's "Agricultural Chemistry," (the last edition.)

The operation of burning exercises the same favorable effect upon the fertility of clayey soils and marls, as the application of lime, and is also capable of greatly shortening the period of fallow by facilitating the degradation and decomposition of the fragments and particles of rocks, stones and sand whence the supplies of the alkaline salts and soluble silica are derived. This is the only effect of burning, which, in my opinion, can only be advantageously practised upon soils abounding in turf. But for fuller information upon this subject also I must likewise refer you to Professor Liebig's work, cited above.

It, of course, depends upon the circumstance of the presence or absence of those materials in the soil, from the degradation of which the desired saline constituents may be obtained, whether or not any benefit can be derived from fallow, or from the influence of those agents and operations which act in a manner similar to fallow, as *burning* or *lime*. Chemical investigation alone is able to indicate the exhaustion of soil, and to ascertain whether an exhausted soil will benefit or not by *fallow*, or by those processes of degradation and decomposition which, as we have seen, it is the design of fallow to produce.

LECTURE XIII.

ROTATION OF CROPS.

GENTLEMEN.—You now perfectly understand that all cultivated plants require for their perfect development certain constituents of the soil, and in my last Lecture I explained to you that it is the purpose of *fallow* to afford a fresh supply of these necessary ingredients when the soil has become exhausted by producing repeated crops. In the preceding Lectures it was demonstrated that plants not only require certain inorganic constituents in various proportions, but different

plants require constituents of various kinds; and this affords us an insight into the utility of the ROTATION OF CROPS,—the subject of the present Lecture.

The practice of rotation of crops has arisen out of pure experience. The practical farmer observed that, in most cases, when the same plants were grown for two, three, or more years consecutively upon the same soil, it did not yield the same abundant harvest; whilst, when another crop was tried upon that soil, the production was satisfactory. Observation and experience subsequently and gradually established for different parts a different alternation of crops, but the practical agriculturist has never been able to devise a fixed rule for every kind of soil; although many efforts have been made to attain this desirable end, the subject has not been able to pass the limit of mere empiricism.

Whilst the practical farmer was content to rest simply upon the facts supplied by his experience, and remained satisfied with believing that some plants exhaust the soil, whilst others do not, the theorist endeavored to discover a key to this remarkable phenomenon. Of all the hypotheses devised to explain it, that of secretion and excretion by the roots of plants seems to have had the greatest number of adherents, because it appears to explain satisfactorily the necessity for the rotation of crops.

According to this hypothesis, all plants secrete or form certain matters during vegetation, which they cast out by their roots, and the accumulation of these in the soil exercises an injurious influence upon future crops of the same plants, but does not interfere with the growth of a different crop; nay, it was further supposed that the excrements of one species of plants might furnish an appropriate nourishment for another species. The framers of this hypothesis, no doubt, imagined that plants in this respect exhibited an analogy with animals, because we see animals turn with aversion from the excrements of their own species, whilst the same excrements are sought and eagerly devoured by animals of a different species. But this supposed analogy is utterly fallacious; and if we examine the adaptation of the hypothesis to the facts of the rotation of crops, we shall find it to be altogether unsatisfactory.

The experiments made to prove that certain matters are secreted by the roots of plants, are by no means conclusive; but, since it is well established that plants possess the power of absorbing and adapting matter for their growth, we may also suppose, in the absence of direct proofs, that they likewise secrete matter by their roots. For brevity's sake, we will admit that such secretion takes place, and enquire into the proofs adduced to render the opinion probable, that these secretions exercise an injurious influence upon the growth of plants of the same species, whilst the same matter favors, or, at least, does not exert any injurious effect upon, the growth and developement of plants belonging to other species.

The facts brought forward to establish this theory are such as these—1st. That fruit trees, planted on the same spot where previously others of the same species had long grown, have not produced so well as usual. 2d. The camomile (*matricaria chamomilla,*) when, to a certain extent, present in a field, interferes with the growth of the cereals, owing, as it is supposed, to its secretions in the soil being offensive to the latter. 3d. After the culture of peas, vetches, clover, lucerne, buckwheat, &c., far finer crops of cereals will be produced than if consecutive crops of grain were attempted.

But, in objection to the theory of the excretions of one plant being injurious to another, we might allege, that it often happens that trees of the same kind will flourish upon spots where they have previously grown; and that in many countries, especially in Hungary, successive crops of grain plants may be grown year after year continually, on the same soil, without disadvantage. In meadows and forests, also, we see the same species of plants succeed each other for ages, and suffer no injury from the accumulation of the secretions of preceding generations. To explain such cases as these would require a new theory to be added to the first, and without the aid of chemistry, this would be as weak and unsatisfactory as we have shown the former theory to be. We must, therefore, reject the hypothesis of the secretions of plants being the cause of the advantage or necessity of the rotation of crops, and endeavor to discover another, capable of affording a satisfactory explanation of the known facts, perfectly consistent with

true science, and especially with chemistry; and if such a theory be thus established, it cannot fail to be of great use in practice.

If we assume that the cause of the utility of the rotation of crops depends exclusively upon the circumstance that cultivated plants withdraw from the soil unequal amounts of certain ingredients for their nutrition, all the observed facts are at once and satisfactorily explained, and the possibility of determining the rotation of crops, or of avoiding it altogether, if desirable, rendered evident.

I need not here repeat what I have already told you in a previous Lecture, (the 11th) respecting those constituents of plants which they derive from the soil, but I must remind you that plants of various species differ very much with respect to the nature as well as to the quantity of mineral or saline constituents which they require for their growth and development.

Bearing this in mind, it is obvious that the growth of a plant may be impeded, simply because the mineral constituents principally needed, indeed essential to their proper developement, have already been drawn from the soil, by the previous cultivation of another plant, requiring nearly or altogether the same constituents. If, for example, we take a field the soil of which contains the mineral and saline materials required to produce wheat, and yet only in a quantity exactly sufficient to produce a single crop, it follows, of course, that a second crop of wheat cannot be reared upon the same field. The soil is completely exhausted for the moment, and will remain so for ever, if it does not contain substances which may by disintegration and decomposition furnish a new supply of the ingredients necessary to the growth of plants, or if these essential matters are not artificially supplied.

Such a complete exhaustion of the soil as we have supposed, for the sake of illustration, to be effected by a single crop, is not very likely ever to happen in fact. But what really happens, and that commonly enough, is, that although all the salts are not exhausted, yet being present in the soil in relative proportions very different to the amounts required by various plants, a single crop of wheat may deprive the soil so completely of one of its mineral constituents, that another crop of wheat would not grow upon it, and yet this soil may still contain abundant mineral constituents for the production of a good crop of clover or turnips.

It will now be obvious that it is possible to grow three, four, or more successive crops of the same grain upon the same fields, whenever the soil contains a sufficient amount of the necessary mineral constituents, and that if a soil possessed an illimitable amount of these substances, or received a constant and sufficient supply of them, it would be able to produce successive crops of the same cereals continually and for ever, and moreover that a rotation of crops would be in such cases wholly unnecessary.

What we have stated with respect to the cereals, applies equally to all other cultivated plants; so that any plant may be grown upon the same field continually, and good crops obtained, if the ingredients of the soil which the plant requires either are present originally to an unlimited amount, or the farmer furnishes the field with a constant and sufficient supply of these substances.

Viewed in this light, the subject will be clearer to you than perhaps has hitherto been the case. You will now understand that an *exhausting plant* must be one which in comparison with other cultivated plants requires many inorganic constituents, and consequently requires for its successful cultivation a soil rich in those constituents. We need by no means wait for the perfect development of a plant, and subsequent trials upon the same soil where it is grown, in order to know whether it is an exhausting plant or not; we can arrive at a positive conclusion upon this point immediately by burning the plant and examining the ashes. The case for example may occur that some hitherto unknown plant is recommended for cultivation, and tried in a soil equally unknown, as to its amount of the constituents which that particular plant may require.

Practical experience, arising from the growth of this plant in one field or soil may pronounce it to belong to the class of *exhausting* plants, whilst in another soil it may be found to be a non-exhausting crop. Thus, the most contradictory conclusions may be drawn from practical experience, and many a farmer has paid the penalty of this uncertainty. It is frequently only after the lapse of a long time, and after a series of successful and unsuccessful trials, that it is at

last found out which soil will suit this particular plant and which will not. All this may be obviated, and the question determined at once, by burning the plant, examining its ashes, and carefully analysing the soil; this will enable us to determine whether a given field will repay the cultivation of the plant or not.

Thus you perceive that the terms, "exhausting" or "non-exhausting plants," are merely relative; a chemical analysis of the ashes of plants, as well as of the soil, can alone enable us to decide upon this point. Strictly speaking, only those plants can be called exhausting which find an insufficient amount of ingredients necessary to their growth present in the soil. So that plants requiring a considerable amount of mineral constituents, such as wheat, for instance, when grown in a soil rich in those constituents, cannot be designated an exhausting crop relatively to the soil; whilst on the other hand, plants requiring but an inconsiderable amount of mineral ingredients, when sown in a soil not adequate to supply even a small amount of these ingredients, must relatively be considered exhausting plants. From the preceding remarks it will be evident how ill-founded the assertion is that certain plants improve the soil by enriching it. It is a fact, proved beyond the power of controversy, that all plants whatever withdraw certain mineral constituents from the soil, and thus so far impoverish it. All such notions of improvement, founded upon practical experience, are mere illusions, as I shall endeavor to make manifest to you by a few illustrations.

It is frequently asserted that fallow crops, such as clover, peas, vetches, lucerne, buckwheat, &c., and even tobacco, potatoes, beetroot, carrots, &c., do not exhaust the soil, but on the contrary are, in a certain measure, capable of improving it. This is especially said to be the case with buckwheat, which is frequently sown during fallow, and subsequently, when nearly in flower, ploughed into the soil in order to improve and enrich it. The power of the soil to produce cereals, after having grown crops of these plants, is thought to prove their non-exhausting nature. The term *fallow crops*, indeed, indicates that fields left fallow in order to restore their fertility for the cereals, have been found by experience to be capable of yielding crops of these plants without their subsequent ability to grow the cereals being affected.

I will now, however, prove to you that a very satisfactory explanation of this matter may be obtained from the analysis of the ashes of these plants.

Buckwheat, the entire plants, including the seeds dried at 86° Fahrenheit, yields 4 per cent. of ashes. The constituents of these ashes, as we have repeatedly seen in the course of these Lectures, must have been derived from the soil. The analysis of the ashes of buckwheat shows that they consist of 29 parts of potass salts, 45 parts of lime and magnesia salts, and 26 parts of silica; and, therefore, that buckwheat must be classed with *lime plants*, since lime and magnesia predominate in its ashes. The cultivation of buckwheat will, therefore, deprive the soil chiefly of its lime and magnesia salts. Now 100 parts of wheat, with the ripe grain, contain 3·3 per cent. of ashes, and these ashes consist of 12 per cent. of lime salts and 51 per cent. of silica. It is obvious, therefore, that the demand which wheat makes upon the soil, where buckwheat has been grown, is of a different kind, since the latter requires a preponderating proportion of lime salts, whilst wheat requires a preponderating proportion of silica. So also with barley, oats, and other white-straw crops (cereals), since barley, taking the straw and grain together, leaves 7·04 per cent. of ashes; oats, 5·73 per cent.; and the analysis of these ashes brings both these under the class of *silica* plants, the ashes of oats containing 62 per cent. of silica and only 4 per cent. of lime salts, the ashes of barley 55 per cent. of silica and 25 per cent. of lime salts. You will now perceive that, to incorporate the buckwheat with the soil, by ploughing it in, instead of removing it, cannot enrich the soil, since this operation can only return to the soil that which the buckwheat had drawn from it.

Silica bears also a very subordinate part in the growth of peas, clover, vetches, lucerne, &c., as the constitution of their ashes clearly proves. The ashes of pea-straw contain 8 per cent.; those of clover, 5 per cent.; of vetches, 9 per cent.; of lucerne, 34 per cent.—of silica. These plants, therefore, do not belong to the class of silica plants; and we see here at once a satisfactory explanation of the fact that silica plants, *i. e.* the cereals, may be grown on the same soil both before and after them.

The same remark applies to beet root and to potatoes, so far as respects the

tubers, which contain only a trace of silica. The ashes of potato-straw indeed contain 40 per cent. of silica, but this, nevertheless, does not bring it within the class of silica plants; and as the potato-plant is usually burnt upon the field, and its ashes returned to the soil, we may assert that neither beet roots nor potatoes exhaust the soil for the cultivation of white straw crops—that is, the cereals. 100 parts of beet roots dried in the open air yield 6 per cent. of ashes; 100 parts of potatoes, (the tubers or roots,) 4 per cent. Both belong to the class of lime and potass plants. Were you to cultivate these plants several times consecutively upon the same fields, without supplying lime and potass salts to the soil in the same proportion as these crops remove them, you would soon discover how exceedingly exhausting these plants are, unless your soil should be naturally unusually rich in these salts.

You now perceive that the term "exhausting," if used without restriction, is altogether fallacious: a soil may be exhausted with respect to beet and potatoes, but remain capable, nevertheless, of yielding abundant crops of wheat. It is, therefore, only in relation to the cereals that the fallow crops may be said to exercise *no* exhausting or deteriorating influence upon the soil.

But practical agriculturists have so long and so generally entertained the opinion that fallow crops enrich and ameliorate the soil, that I must trouble you with some further remarks to correct this error.

In most cases where it has been proved by experience that a second crop of cereals could not be grown upon a field immediately after a first crop, the custom has been to cultivate a fallow crop after the harvest of the grain, since it was found that the soil by this means recovered more or less its former fertility. It was quite natural for the farmer to think the fallow crop had improved the soil; and theorists sought to explain the matter by the notion of *humus*, and by supposing that there was some secretion formed by the roots of plants. Their explanation was this;—"Fallow crops consume the secretions of the last reaped grain crop, and in return secrete matter which serves as nourishment to a subsequent crop of grain;" or perhaps this:—"The soil exhausted by the cultivation of the cereals needs rest: this rest is not disturbed by the fallow crops, so that the soil may recover during their growth, and subsequently produce corn again." In both these theories, particular stress was laid upon the circumstance, that by leaving the roots of the fallow crops in the soil, or, still more, by incorporating the entire plant with the soil, *humus*, the supposed nourishment of all plants, is supplied. The facts and experience opposed to these assumptions were of course altogether disregarded. The soil after pure fallow is more productive than after fallow crops have been cultivated. This was quite overlooked, and yet it is inconsistent with, and fatal to these theories. So also the effects of disintegration and decomposition of the inorganic constituents of the soil, which must occur more or less, as the period of the fallow is more or less extended. We have seen, in a former Lecture, that the degradation of minerals proceeds incessantly in the soil, and gives rise to the formation of the inorganic constituents of plants, and especially of alkaline carbonates and soluble silica; and a sufficient amount of these substances for the successful cultivation of wheat or other silica plants, may be formed only in the course of two or three years, by the decomposition of the felspar and other rocky masses, stones, &c., in the soil. From a soil where this happens, a crop of wheat can only be expected once in two or three years; and in the interval the soil must be left fallow, for the process of decomposition to restore the necessary amount of soluble saline constituents. As far as the wheat crop is concerned, it is a matter of indifference whether the field has been left entirely fallow, or a fallow crop has in the interval been grown upon it, provided the latter requires totally different constituents of the soil for its growth from those required by wheat. The field reäcquires by fallow its original power of producing wheat; but the notion that this is effected by the fallow crops, and not by the fallow itself, is wholly unfounded.

A just appreciation of the importance of the saline constituents of the soil, and a comparison between the ashes of the fallow plants and those of wheat, afford a perfectly satisfactory explanation of this subject—a THEORY which embraces all the facts, and agrees with all well-established experience.

There are certain other circumstances, closely connected with the apparent amelioration of the soil by fallow crops, which require our notice. It is a well-

known fact, for instance, that the roots of all plants do not penetrate to an equal depth into the soil; on the contrary, whilst some are spread on its very surface, others extend deep into the lower strata. The former, therefore, can only derive their saline constituents from the uppermost layers, whilst the latter draw them from some depth; and by using them in the formation of parts above the ground, tend ultimately to bring them upon the surface. Some advantage may, therefore, accrue from cultivating certain plants as fallow crops, the roots of which penetrate deep into the soil, and subsequently incorporating these crops with the upper portion of the soil, thus enriching it with their saline constituents derived from beneath. To those who are ignorant of the nature and importance of the mineral constituents of the soil, this may appear to favor the opinion that fallow crops improve the soil. It is, perhaps, with some such view, that lucerne and saintfoin are grown as fallow crops, their roots being left in the soil, and that buckwheat is grown and ploughed into the soil, since the roots of these plants penetrate far deeper than the roots of the cereals.

This principle finds a positive and useful application in the very sterile soils of certain heaths, where a crop of cereals is obtained once in 30 or 40 years by burning the heath plants, and mixing their ashes with the upper surface of the soil. By this means the mineral substances drawn by the heaths from no inconsiderable depths, during many years, are at once transferred to the surface, and made available to a crop of wheat or other grain.

Before concluding this Lecture, I would impress upon your minds, once more, the importance of a classification of plants into silica plants, lime plants, and potass plants, according to the constituents of the soil which predominate in their ashes, and which, consequently are required for their growth and development. You are already, I trust, assured, from the statements I have made in the present Lecture, and in the former one on fallow, that the mineral constituents of the soil perform a most important part in the growth of all cultivated plants; and what I have further to tell you, in the next Lecture, upon manuring, will deepen your conviction of the same important practical truth. The necessity for inorganic matters to the nourishment of plants, is the ground of the use and employment of fallow; the rotation of crops depends upon the necessity for different *proportions* of the several kinds of these ingredients: and, as we shall more fully explain in the next Lecture, the essential point in manuring is to supply to the soil inorganic soluble substances, in which it may be either absolutely or relatively deficient.

To recapitulate briefly: by *fallow*, the greatest possible amount of the mineral substances in the soil are rendered soluble in water, and therefore capable of being assimilated by plants; by *rotation of crops* the rational agriculturist consumes, with the greatest possible economy, the inorganic constituents naturally present, or artificially supplied to the soil; and, finally, *manuring* has for its object the due supply of these soluble mineral constituents.

With respect to the question whether rules may not be devised for the rotation of crops,—their utter futility, independent of a very complete knowledge of the nature of the soil, has long been recognised. Chaptel, in his "Manual," observes—"To lay down general rules for the regular rotation of various crops, without regard to the differences in various soils, would lead to errors tending to bring rotation altogether into disrepute. . . . . . . Every kind of soil requires a particular system of rotation, and every farmer must arrange his own system according to his especial knowledge of the nature and composition of the soil of the fields he cultivates."

LECTURE XIV.

ON MANURES.

General Considerations Respecting Manures.

GENTLEMEN:—The soil under cultivation, in all civilized countries, is at present, with few exceptions, in such a state that neither fallow nor rotation of crops can impart to it permanently that degree of fertility necessary for the successful growth of cultivated plants. Continual harvests have, in the course of time, gradually withdrawn from the soil so great an amount of its mineral constituents, that a want of them is almost everywhere very sensibly felt; so that it has become the principal object of agriculture to replace artificially those substances which have been taken away from the soil in the crops.

If the supply furnished to the land be insufficient, increased sterility is the necessary consequence; if sufficient to replace what has been removed, the productiveness of the soil remains the same as it was before the growth of the last crop; if a superabundance be supplied, the fertility of the land is increased. Manuring, therefore, is designed to replace, as completely as possible, the inorganic constituents of the soil which have been carried off by the last crop, or to supply a surplus of these ingredients.

Plants derive from the soil only inorganic matters, (certain salts and soluble silica,) which we may reöbtain in the form of ashes, by burning the plants. To restore these ingredients to the soil, only two ways are open to us: first, to burn the plants, and strew their ashes on the fields where they grew; or, secondly, to observe where these substances are dispersed by the uses made of plants, to collect them as carefully as possible, and restore them to the fields. It is obvious that the first method cannot answer our purpose, since we do not cultivate plants in order to burn them, and to manure the fields with their ashes, but because we expect to derive advantages from them, such as the nutrition of man and of animals, and their employment in the arts and manufactures. We are, therefore, restricted to the second method, which is, of course, far more circuitous than the first.

Let me, in the first place, contemplate this subject from a theoretical point of view, and afterwards compare the results so obtained with those arrived at by mere experience. You will be interested to observe how much, in this case, theory agrees with practice.

If we keep in mind that no vegetable substance can be properly employed as manure, so long as any advantage can be obtained from its uses for other purposes, and, therefore, that the inorganic constituents of the plants cannot be restored to the fields, until all the parts of the plants employed for various purposes have wholly fulfilled them, we shall find it necessary to study carefully their many applications, and the various transformations which take place in vegetable substances, during their uses, in order to lose none of their inorganic constituents.

It is not difficult to trace what becomes of the plants taken from the fields; there are only three principal channels through which all their parts can pass, from the moment they are gathered, until the period when they can usefully serve no other purpose than for manure. They are used for the nutrition of animals, which are finally consumed by man, or directly as food for man, or their parts which are unfit for food are applied to some economical purpose, as the straw, for instance, to litter animals, &c.

In studying the passage of vegetable matters through the bodies of animals which have fed upon them, we find their several constituents subserve various purposes in the animal organism. The carbonaceous constituents of plants are chiefly applied to the support of the respiratory process, and for the production of animal heat, and in these processes they are converted into carbonic acid and water, and are thus restored in their original form to the atmosphere whence they are derived. The nitrogen of the nitrogenous constituents of plants, after having served the purposes of nutrition, passes out of the animal body in the

urine, in the form of urea, uric acid, &c.; the decomposition of these substances in the putrefaction of the urine converts their nitrogen into ammonia, and thus it is restored to the atmosphere in the same form in which it was originally derived from it. Thus all the constituents of plants which they have derived *from* the atmosphere are returned again *to* the atmosphere.

Those constituents of plants which they derived from the soil, and which serve for the nutrition of animals, may be divided into two classes; 1st, such as pass through the intestinal canal, unabsorbed, and become evacuated with the fæces; and 2d, such as are taken into the system, assist in the formation of blood, and the proximate constituents of the animal body, the muscles, bones, &c., and after various transformations are separated from the organism, being secreted by the kidneys, and passing out in the urine. Hence it is evident that by collecting the excrements and urine of living animals, we obtain possession of all the inorganic constituents which plants derive from the soil, and we are thus enabled to return these substances to our fields.

It is precisely the same with respect to the inorganic constituents of plants which have been used as the food of man; they are found in the human excrements, both fluid and solid. And it is, moreover, quite clear that such of the inorganic constituents of plants as have served for the nutrition of animals, which in their turn have been eaten by man, pass through the human body in the same way, and are to be found in the urine and fæces. The phosphate of lime stored up, as it were, in human bones, and, according to our modern customs, buried in the grave, is withheld for a longer period from becoming useful, by being returned to the soil.

But these bones crumble into dust, and, sooner or later, are restored to the soil to serve for the nutrition of plants, thus entering again into the general circulation of matter.

The animal body has been likened to a furnace in which vegetable substances are burned, where everything assumes a gaseous form, and escapes into the atmosphere, with the exception of the inorganic or mineral constituents of the plants; these remain in the furnace in the form of ashes, whilst from the animal body they are evacuated in the fæces and urine. The ashes of the furnace after combustion, and the fæces and urine of animals, consist of exactly the same ingredients.

Finally, those parts of plants which serve neither for the nourishment of man nor of animals, but for other purposes, such as straw for litter, &c., it is no matter to what purposes they may have been applied, their inorganic constituents, when they have served every possible use, may be collected and restored to the soil.

From these data it distinctly follows that, according to theory, the most natural and simple way of manuring land is, the application of the fæces and urine of man and of animals, all animal excretions, offal, bones, dead bodies, &c., together with the straw employed for litter, since we thus restore to the soil everything which has been removed in the harvest.

Of course it is impossible to suppose that we are capable of restoring *everything* which has been taken off from the land. Some of the materials will be lost, not, indeed, in the great economy of nature, but from the narrower sphere of a country, a province, and still more from a single farm. It is on this account that experience has shown the necessity of some substitute for, or addition to the above-named manures, of which we shall speak more fully hereafter.

You well know, Gentlemen, that the employment of the substances, before mentioned as manures, has not been adopted from any theory; on the contrary, it has been the result of experience. The practical experience of a thousand years has established the benefit of employing animal excrements, decayed vegetables, straw, &c., for manuring the land. Only recently, however, a theoretical explanation of the favorable influence which these manures exercise upon the fertility of the land, has been sought for and discovered.

When I say a scientific theory has been only very recently established, respecting the nature and effects of manures, I must be understood literally, because the humus theory, hitherto much in vogue, ascribed the efficiency of manure principally to its supplying the new crops with the carbon and nitrogen necessary for their nourishment and growth. But we have seen that these elements are derived from the atmosphere, and not from the soil; so that the benefit of ma-

nure consists exclusively in the supply of the salts and soluble earthy matter, essential to the development of the plants.

Let me again refer you to what I told you in the eighth and ninth Lectures, respecting the carbon and nitrogen of plants. You will recollect that I gave you the general results of certain chemical examinations of manure, and of the crops derived from the fields to which this manure had been applied. These investigations proved that there must be other sources of carbon and nitrogen than the manure. I must now give you a more detailed account of these investigations, since a just appreciation of the truths which they teach us, is of the greatest importance in practice. The experiments which I am about to detail were made in France.

Various crops were grown upon one hectare of land during five consecutive periods, supplied with animal manure, and the most suitable rotation was followed.

In the first period, embracing five years, the total weight of the crops was 80,836 pounds, consisting of potatoes, wheat, clover, wheat, oats, in this order of rotation. The weight of the manure used was 98,172 pounds. This reckoning includes the moisture of both the crops and the manures. In order to arrive at the most accurate results, the manure and the crops were dried at the same temperature, and in the same manner; and then it became manifest that the weight of the crops exceeded that of the manure employed. The dry crops weighed 35,582 pounds, whilst the dry manure weighed only 20,322 pounds, giving a surplus of 15,260 pounds to the crops. By careful analysis it was found that the crops contained:—

16,766	pounds of carbon
1,946	" of hydrogen
14,346	" of oxygen
502	" of nitrogen
2,022	" of salts and earths
35,582	

The manure used to produce these crops contained

7,275	pounds of carbon only
853	" of hydrogen
5,244	" of oxygen
506	" of nitrogen
6,544	" of salts and earths
20,322	

Thus you will perceive that the crops contained 9,491 pounds of carbon, and 96 pounds of nitrogen more than the manure; and on the other hand they contained 4,522 pounds of salts and earths less than the manure.

In the second period, embracing also five years, the same results were obtained. The rotation followed was, beet, wheat, clover, wheat, turnips, oats. The total weight of the crops in a dry state amounted to 34,956 pounds, whilst the dry manure employed amounted only to 20,322 pounds.

In the third period, embracing six years, the sum total of the crops was 46,660 pounds, the manure employed 24,384 pounds. The rotation followed was, potatoes, wheat, clover, Swedish turnips, peas, rye.

In the fourth period of three years, the field was left fallow the first year, and the two following years sown with wheat. The weight of the two wheat crops was 16,772 pounds, whilst the weight of the manure employed was only 8,280 pounds.

Finally, in the fifth and last period, the Jerusalem artichoke (*Helianthus tuberosus*) was cultivated for two consecutive years, and the weight of the roots and stalks, when dried, was 71,124 pounds. The manure employed was 18,816 pounds.

Placing all the results together in a Table, we find the following:—

	Crops.	Manure.	Surplus.
In the first period	35,582	20,322	15,260
In the second period	34,956	20,322	14,634
In the third period	46,660	24,384	22,276
In the fourth period	16,772	8,280	8,492
In the fifth period	71,124	18,816	52,308

Thus we see that there was in none of these periods a sufficient amount of carbon, hydrogen, oxygen, and nitrogen, contained in the manure, to supply the demands of the plants, since, in all cases, a larger quantity of these elements were found in the crops than in the manure supplied to the land.

The following Table will show the surplus amount of each of these elements in the crops, as compared with the quantity of each in the manure :—

	Carbon.	Hydrogen	Oxygen.	Nitrogen.
In the first period	9,491 lbs.	1,093 lbs.	11,103 lbs.	95 lbs.
In the second period	9,110 "	1,059 "	8,775 "	102 "
In the third period	13,171 "	1,513 "	12,518 "	219 "
In the fourth period	5,023 "	569 "	4,643 "	9 "
In the fifth period	25,239 "	3,138 "	27,121 "	172 "

On the other hand, the amount of the salts and earths supplied by the manure was, in every case, far greater than the amount removed from the fields in the crops, and the result, of course, must have been that, during the five periods, the soil became richer in saline and earthy constituents than it was at the beginning. The fact, that the continuous cultivation of land with constant and simultaneous manuring tends to enrich the soil and to render it more and more fertile, has long been known and acknowledged, but the cause of it—the rationale—was not by any means understood. Soil, cultivated and manured for many successive years, is brought into a high state of cultivation, as it is termed, since it will produce repeated crops without the further addition of manures, until after many harvests the salts and earths which had accumulated in the soil are at length consumed, and the soil becomes again exhausted.

The following table exhibits the difference in the respective quantities of mineral ingredients supplied to the soil by the manures, and carried off the land in the crops.

	Mineral matters supplied to the soil in manure.	Mineral ingredients carried off the fields in the crops.	Surplus of saline and earthy matters left in the soil.
In the first period	6,544 lbs.	2,022 lbs.	4,522 lbs.
In the second period	6,544 "	2,131 "	4,413 "
In the third period	7,851 "	2,706 "	5,145 "
In the fourth period	2,666 "	913 "	1,753 "
In the fifth period	6,058 "	2,494 "	3,564 "

Thus, during 21 years, whilst these experiments were in progress, a surplus of no less than 19,397 pounds of mineral substances, saline and soluble earthy constituents, were supplied to the land in the manures; at the same time, the results of the incessantly progressing degradation of the stones and mineral masses in the soil, added to the former, may be readily admitted to be sufficient to permit the growth of plants for many successive years without the farther addition of manures.

Whatever may be the inferences you are disposed to draw from the preceding experiments and facts—which you will find reported more in detail, in Liebig's "Agricultural Chemistry"—so much is certain, that it is quite impossible to understand and to explain the action and known influence of manures upon the old humus theory, and that we must look to the mineral constituents of plants for a correct explanation of the uses and effects of manures. This is in fact the main principle of the new theory. The new theory of manuring rejects the usual definition of manure, together with the distinction between stimulating and nutritive manures. It recognises no stimulating manures, but it considers all manures which are of any value as nutritive substances, that is, matter capable of ministering to the nourishment of the plants by supplying the essential saline and soluble earthy matters. The classification of manures, which we shall adopt in the succeeding Lectures, is, therefore, founded upon the origin of the various kinds of manures, and we shall divide them into Vegetable, Animal and Mineral Manures.

LECTURE XV.

VEGETABLE MANURES.

Green Manure....Humus....Ashes.

GENTLEMEN:—At the conclusion of my last Lecture I announced my intention of treating upon manures under the several divisions of Vegetable, Animal and Mineral Manures, guided in this classification solely by the origin of the several substances employed as manure; our attention in this Lecture will be confined to vegetable manures. These, again, I shall subdivide into three classes: 1st. *Green Manure*—or plants used in their fresh and undecomposed state; 2d. *Humus Manure*—plants used after having undergone a more or less degree of decay or putrefaction; 3d. *Ashes Manure*—the ashes remaining after the complete combustion of vegetable substances.

GREEN MANURES.

The practice of manuring with green vegetables is rarely carried out to its fullest extent; the crops most frequently employed for this purpose are buckwheat and clover; we shall, therefore, confine our attention to the effects and uses of incorporating with the soil the whole substance of a crop of buckwheat, for example, after it has arrived at maturity. The opinions of practical farmers, derived from experience, differ very widely with respect to the utility and advantages of this kind of manure. Most persons who have tried it carefully, have concluded that the benefit derived from it in the subsequent crops of grain, by no means repays the necessary cost and labor. All, however, seem to have agreed in ascribing whatever favorable effect it may exercise on the subsequent harvest, to the formation of humus in the soil. I think, however, that I can offer you a better and more satisfactory explanation of the effects of green manuring than is furnished by the humus theory.

In the first place, then, buckwheat is sown during fallow, that is, in the interval of the growth of the cereals, whilst the incessantly progressing degradation of the minerals in the soil enriches it with the saline and soluble earthy constituents necessary for the successful cultivation of the cereals.

Secondly, the seeds of buckwheat contain no inconsiderable amount of mineral constituents, and more especially of phosphoric acid, which being incorporated with the soil, may prove of some benefit to the succeeding crop of cereals.

These seeds yield upon incineration, 1·52 per cent. of mineral matters, which are constituted as follows:—

	In 100 Parts.	
Substances soluble in water	54	Potass, Soda, Carbonic Acid, Sulphuric Acid, Chlorine.
	In 100 Parts.	
Substances soluble in hydrochloric acid	36	Lime, Magnesia, Alumina, Peroxide of Iron, Phosphoric Acid,
Residue	10	Silica.

Thirdly—and this is by far the most important circumstance to be considered, in explaining the influence of buckwheat upon the subsequent fertility of the soil—this plant has the power of transferring, by means of its deeply penetrating roots, certain mineral ingredients from the lower to the upper layers of the soil.

You know very well that plants do not send their roots to equal depths in the soil, and that some plants, the cereals especially, spread their roots merely into the most superficial parts, and consequently they draw their supply of nourishment only from the uppermost soil; and however rich in saline and earthy mat-

ters suitable to these plants the deeper layers of the soil may be, they are not available to these plants, since their roots cannot penetrate down to them.

Now, if we cultivate a plant with deeper roots than the cereals possess, such as buckwheat for example, upon a field the surface of which has been exhausted by the cultivation of cereals, it is quite natural to expect that the lower strata of the soil should afford the necessary mineral ingredients for the luxuriant growth of the deeper rooted plants.

And if, when the latter plants are more or less developed, we take care to incorporate them with the soil instead of removing them from the field, the mineral constituents of the leaves, stems, and to a certain extent, of the roots, will be transferred to the upper layers of the soil; the putrefaction and decay of those parts of plants liberate the mineral matters, in a state capable of being assimilated by subsequent crops of plants the roots of which derive nourishment only from near the surface. Thus it is that buckwheat may benefit the subsequent crop of cereals. It may be objected to this view of the matter, that buckwheat being decidedly a lime-plant, must transfer from the lower to the upper surface of the soil chiefly such ingredients as are of no use to the cereals, the latter being silica plants. But we may imagine instances where the surface of a field contains a sufficient amount of silica, and yet is deficient in the sulphates and phosphates of lime and potass,—salts equally essential to the growth and development of the cereals, although only to an inferior amount. It is obvious that in such cases, the growth of buckwheat and its subsequent incorporation into the soil may prove advantageous to the cultivation of cereals, by supplying a certain amount of the necessary phosphates and sulphates of lime and potass.

With respect to the formation of humus in the soil, from the incorporated buckwheat plants, it cannot be controverted that humus is formed in this manner of manuring; but I think I have abundantly proved to you in the course of these Lectures, that this humus contributes nothing toward the support of the cereals, except the mineral ingredients which were contained in the plants from the decay of which it was formed.

Taking everything into consideration, I think we are justified in asserting that the direct advantages of green manure are very insignificant, and, moreover, may be obtained with far greater facility by other methods of manuring. The indirect advantages derivable from green manuring are exclusively owing to the simultaneous application of fallow and the rotation of crops, since in order to manure with green crops, silica plants are alternated with lime plants.

The same remarks are applicable to all green crops employed as manures, to lupins, clover, and all fallow crops, and to the cultivation of saintfoin, lucerne, &c., the leaves and stems of which are used as fodder for cattle, whilst the roots and part of the stems are left in the soil, and whilst still green and fresh incorporated into it by ploughing.

HUMUS MANURE.

By humus manure we understand plants or parts of plants in a state of decay. The straw of the cereals, the stems of cultivated plants not suitable for fodder, the fallen leaves of trees, and generally all vegetable refuse, come under this denomination, as they are carried to the fields wholly or in part converted into humus. In most cases these vegetable matters are more or less accidentally or intentionally mixed with animal substances, in consequence of the uses to which they have been previously applied, such for instance as the straw employed for litter; but this need not interfere with our examination and correct apprehension of this subject; and it will be useful to have an especial and precise notion of the nature and effects of vegetable substances when employed as manures.

In order to have a clear apprehension of this matter, let me recall to your mind what I have already stated with respect to humus, in the sixth Lecture, namely, that vegetable humus is formed by the decay of plants or parts of plants, and that in the process of decay, carbonic acid and ammonia are evolved, and upon the completion of the process, and the entire dissolution and destruction of the humus, nothing remains behind but the inorganic matters, which the plants themselves would have left in the form of ashes, had they been burnt instead of undergoing the process of decay. Such a thing, therefore, as vegetable humus without mineral constituents cannot exist, and all inferences drawn from the

favorable effects of humus upon vegetation, without regarding these ingredients, must be altogether fallacious, since they proceed upon the assumption of properties belonging to a substance altogether unknown.

De Saussure found by experiment that humus originating in the decay of oak-wood left, upon combustion, 4 per cent. of ashes, and that humus produced by the decay of the whole plant of a species of alpine rose (*Rhododendron ferrugineum*) left upon incineration 14 per cent. of ashes. These ashes exhibited the following constitution in 100 parts:

Carbonate of Potass	14
Hydrochlorate of Potass	23
Sulphate of Potass	16
Phosphate of the Earths	17·25
Carbonates of the Earths	21·50
Silica (Silicic acid)	3·25
Iron, Manganese and Loss	5
	100·00

And the case is the same with the several kinds of humus originating in the decay of straw, leaves, or any other vegetable substances, upon incineration they invariably yield ashes containing the same salts and earths as the ashes of the plants whence they are derived.

It is upon these salts and earths that the efficacy of humus as a manure essentially depends; the carbonic acid formed, and the small amount of ammonia liberated during its decay, perform but a very subordinate part. This is evident, from facts and observations derived from practical experience. Every farmer knows that the various kinds of humus differ in degree as to their nutritive properties, and consequently that they are of very different and unequal value; these differences are inexplicable so long as we ascribe the effects of humus to the evolution of carbonic acid, and the minute amount of ammonia it yields; but when we once understand that the value of vegetable humus as a manure depends upon the earths and salts contained in it, we can clearly account for the different value of various kinds. Thus we perceive why straw, for instance, should be so valuable as a manure for the cultivation of the cereals, since we know it contains all those mineral ingredients which the plants require from the soil for their full development. Humus originating in the decay of silica plants will have the highest value as manure for the cultivation of silica plants, whilst the humus derived from lime plants will serve best as a manure for lime plants, &c. &c. The conclusions derived from practical experience completely bear out and confirm the new theory of manures, whilst they stand directly opposed to the old theory. The principle of the new theory is, that the chemical action of vegetable manures upon the soil depends solely upon the salts and earths contained in them.

ASHES MANURE.

Assuming, then, that our new theory of manures is established both upon the results of practical experience and scientific reasoning; we may assume that it is altogether indifferent whether the salts and earths needed for the crops are carried to the soil in humus, or whether we apply them in the shape of ashes, which we have obtained by the incineration of vegetable substances. A great many practical experiments support this theoretical assumption. The ashes of vegetable substances are in many instances successfully employed as manure. The burning of potato plants and other refuse upon the fields, and spreading the ashes, is frequently practised. The favorable effects of wood ashes, of the ashes of turf, and the several varieties of coal, and of the saline matters left as a residue in the manufacture of soap, have long been known, and their application in manuring practised, especially for grass lands. Should there be no especial reason for the use of humus as manure, such, for example, as its mechanical operation on the soil, (*vide* Lect. vii.,) or the very slow and gradual supply of its salts and earths, which thus economises the amount in a given time; there will be no necessity to await the gradual decay of humus, and the slow process of liberating these earths and salts; the ashes obtained by burning the vegetable substances may be employed with equal or greater advantage.

Professor Liebig has mentioned, in his "Agricultural Chemistry," a very striking illustration of the uses and value of ashes as manures. In the neighbor-

hood of Heidelberg, the wood-cutters have the privilege of cultivating, for their own advantage, portions of land from which the trees have been cleared. The soil consists chiefly of sandstone, and although admitting the growth of trees, is altogether sterile for any kind of grain; but by burning the branches, leaves and roots of trees, and applying the ashes to portions of the soil, they are able successfully to cultivate the cereals.

In concluding this Lecture, I must observe that when we have once admitted the efficacy of manuring the vegetable ashes, it is no longer difficult to conceive that, in the absence of a sufficient amount of vegetables available as manure, we may with equal advantage substitute for them chemical preparations which resemble as closely as possible, in their constitution, the various kinds of vegetable ashes for which they are intended to be substituted.

There is still one more remark before we conclude, which must not be passed over. The design of manuring is in most cases, and chiefly, to induce a more vigorous growth and productiveness of the cereals. Now, it is obvious that for the attainment of this object, the substances employed for manure must contain such salts and earths as the cereals require for their development, so as to supply any deficiency in the mineral constituents of the soil. Thus, if a soil intended for the cultivation of the cereals be deficient in the phosphates, for instance, it is certain that vegetable manure will be of no use, because all those parts of plants which are useless for any other purposes than manure, contain only a very minute amount of phosphates. Vegetable manure will prove more advantageous if the soil be deficient in sulphates, but it is unquestionably of the highest use in cases where the soil does not contain a sufficient amount of available silicates; in this case the straw of the cereals is of the greatest use and efficacy as manure.

LECTURE XVI.

ANIMAL MANURES.

Composition of Fæces and Urine....Dung Manure....Poudrette....Bone Manure....Other Animal Substances....Urine....Guano....Ammoniacal Salts.

Gentlemen:—In my fourteenth Lecture I explained to you that portions of the mineral constituents of plants, or rather of those parts of plants which serve for the nutrition of man and animals, are absorbed into the blood, and enter into the constitution of the bones and the various tissues of the body, and afterwards, in the course of the incessant alterations and transformations of matters going on in the animal body during life, are eliminated from the organism in the urine; whilst other portions pass unaltered through the intestinal canal, and are expelled from the body as fæces. Since it is the purpose of manuring to restore to the soil all the matters which have been withdrawn from it by plants, it is obvious that the fæces and urine of man and of animals employed for this purpose must be a very direct means of effecting this restitution.

The following Tables, the results of the chemical analysis of different kinds of fæces and urine, will show you the composition of these excrements:—

Fresh Horse's Dung contained in 100 parts (the horse was fed with oats, straw and hay)—

3·7	of biliary matter and coloring matter in a state of alteration.
6·3	of mucus, (crude,) &c. &c.
20·2	non-digested vegetable remains and ashes.
69·8	of water.
100.0	

The amount of ashes was 6 per cent. Their constitution, according to Jackson, was as follows, in 100 parts:—

5	Phosphate of Lime.
18·75	Carbonate of Lime.
36·25	Phosphate of Magnesia.
40	Silicic acid.
100·0	

Fresh Cow's Dung contained in 100 parts (the cow was fed with potatoes, beans, straw, and hay)—

2·2	of bile, in a state of alteration.
8·3	mucus, &c.
14·1	non-digested (crude) vegetable remains and ashes.
75·4	water.
100·0	

The ashes amounted to about 6 per cent.: their constitution, according to Haidlen, was as follows:—

10·9	Phosphate of Lime.
10·0	Phosphate of Magnesia.
8·5	Perphosphate of Iron.
1·5	Carbonate of Potass.
3·1	Sulphate of Lime.
63·7	Silicic Acid.
2·3	Loss.
100·0	

Horse's Urine contained in 100 parts, according to Vauquelin—

1·1	Carbonate of Lime.
0·9	Carbonate of Soda.
2·4	Hippurate* of Soda.
0·9	Hydrochlorate of Potass.
0·7	Urea.†
94·0	Water.
100·0	

Cow's Urine contained in 100 parts, according to Brande—

1·5	Hydrochlorate of Potass and Ammonia.
0·6	Sulphate of Potass.
0·4	Carbonate of Potass.
0·3	Phosphate of Lime.
0·4	Urea.
96·8	Water.
100·0	

Human Fæces contained 15 per cent. of ashes, which, according to Berzelius, are constituted as follows:—

67	Phosphate of Lime, Phosphate of Magnesia, Sulphate of Lime (traces.)
5	Sulphate of Soda, Sulphate of Potass, Phosphate of Soda.
5	Carbonate of Soda.
11	Silicic Acid.
12	Carbon and loss.
100	

Human Urine, according to Berzelius, was composed as follows, in 1000 parts:

30·10	Urea.
17·14	Lactic Acid (?), Lactate of Ammonia (?)‡ extractive Animal Matter.
1·00	Uric Acid.
0·32	Mucus
37·1	Sulphate of Potass.
3·16	Sulphate of Soda.
2·94	Phosphate of Soda.
1·65	Phosphate of Ammonia.
4·45	Hydrochlorate of Soda.
1·50	Hydrochlorate of Ammonia.
1·00	Phosphate of Magnesia and Lime.
0·03	Silicic Acid.
933·00	Water.
1000·00	

To these analyses I will add those of GUANO, a substance which has of late assumed great importance in agriculture. Guano (from the word "Huanu," *fæces*,) is an earthly substance of a light-brown color, penetrating odor, and

* Hippuric acid is an organic acid, occurring in the urine of the herbivorous animals, and especially in that of the horse; it contains 8 per cent. of Nitrogen.

† Urea is a compound organic substance, invariably present in the urine of man and of the higher class of animals: it is distinguished by the very considerable proportion of Nitrogen it contains, (47 per cent.) The amount of Urea is particularly great in the urine of the carnivorous animals.

‡ Liebig has recently shown that human urine contains no lactic acid, but always hippuric acid.

strongly saline taste. It is derived from the decomposition of the excrements of various kinds of sea-birds, which feed chiefly upon fish. It is brought, as you well know, from the South Sea coasts, and recently it has been found in considerable quantities on the coast of Africa.

The following are analyses of two varieties of Guano, met with in commerce:

	Guano of Liverpool. (Bartels.)	Guano of Lima. (Völkel.)
Hydrochlorate of Ammonia	6·500	4·2
Oxalate of Ammonia	13·351	10·6
Urate of Ammonia	3·244	9·0
Phosphate of Ammonia	6.250	6·0
Ceral (waxy) substance	0·600	00·0
Sulphate of Potass	4·227	5·5
Sulphate of Soda	1·119	3·8
Phosphate of Soda	5·291	00·0
(Double) Phosphate of Ammonia and Lime	4·196	2·6
Hydrochlorate of Soda	0·100	00·0
Phosphate of Lime	9·940	14·3
Oxalate of Lime	16.360	7·0
Alumina	0·104	00·0
Residue insoluble in Nitric Acid	5·800	4·7
Loss (Water, Ammonia, Organic Matter)	22·918	32·3
	100·000	100·0

The preceding tabular results of analyses will show you, not merely that fæces and urine contain certain mineral ingredients, which are recognised as the same which cultivated plants withdraw from the soil, but, on comparing them together, you will perceive that there exist considerable differences between the various kinds of fæces and urine.

Thus you find silicic acid present in all the different kinds of excrement; but, whilst the ashes of cow's dung contain 63 per cent., and of horse's dung 40 per cent. of this substance, the ashes of human fæces contain only 11 per cent. Or, if you look at the relative proportions of phosphates, you will find similar differences, but inversely—the ashes of cow's dung containing scarcely 30 per cent., those of horse's dung 41 per cent., whilst the ashes of human excrement contain nearly 70 per cent. of these salts. It would be a great error to suppose these differences to be merely accidental: so far from this, it can be positively proved that this difference in the constitution of the excrements of various animals depends upon the nature of the aliments partaken of. The cow fed upon hay, straw, potatoes, vegetable substances, in the ashes of which above 60 per cent. of silicic acid is found; the latter substance, being incapable of assimilation by the animal organism, is expelled with the fæces. The small amount of phosphates in cow's dung, is accounted for in the same manner. If the horse is fed upon straw, hay and oats, and we consider that the grain of all the cereals contain a considerable amount of phosphates, as compared with other parts of the plants, we have a satisfactory explanation of the larger amount of phosphates and the smaller amount of silicates contained in horse's dung, as compared with cow's dung. The same relative proportion of silicates and phosphates would be found, if the fodder of the horse and that of the cow were burned, and the ashes examined.

The food of man consists principally of wheat, flour and animal flesh, substances the ashes of which are exceedingly rich in phosphates; hence the large proportionate amount of phosphates (70 per cent.) and the inferior amount of silicates (11 per cent.), found in the ashes of human excrements.

In the same manner, when we compare the constitution of the urine of the various species of animals, we find differences, to no inconsiderable extent, although less important, with regard to the amount of salts and earths, than to the general organic compounds contained in urine, especially uric acid and urea. When we consider that the salts and earths eliminated in the urine are those which, being absolutely necessary for the nourishment of the animal body, have entered the circulation, and have been subsequently separated from the blood in the course of the incessant changes proceeding in the organism; and further, that animals of the higher classes all require for their nourishment nearly the same salts and earths, we can understand why the urine of different kinds of animals exhibits no material difference with regard to the relative amount of these salts and earthy matters.

The analyses of the urine of the horse and the cow, which I have given above, are in as far defective as the amount of the phosphates which they invariably contain is not stated. *Vauquelin* probably took no notice of them, because at the time those analyses were made they were deemed of no importance, whilst the organic constituents of the urine, the urea and uric acid contained in it, were considered as the most important ingredients. The phosphates only appeared to be of interest, inasmuch as in certain diseases of man and animals they accumulate in the bladder in the form of stone.

The error of estimating the value of urine as a manure, by its amount of organic constituents, is too obvious to need repetition here. It may be questioned whether the organic matters of urine are of any use in promoting vegetation, but it cannot be questioned whether the inorganic constituents are of use, since we know with positive certainty that they—and more especially the phosphates, as I shall show you in the sequel—exercise a powerfully fertilising influence upon the soil.

I have stated that urine of different animals varies in composition chiefly with respect to the amount of urea, uric acid, and other organic compounds, which it contains. The tables given above exhibit these differences very clearly. Thus, whilst 1000 parts of the urine of the cow contain only four parts of urea, and 1000 parts of the urine of the horse seven parts, human urea contains thirty parts of urea in 1000. Urea and uric acid, by decomposition, form a large amount of ammonia; and we may observe again here, that it is chiefly by the dissolution of these organic substances that the ammonia withdrawn from the atmosphere, in vegetation, after passing through various transformations, and forming the nitrogenous constituents of vegetable and animal bodies, and undergoing other changes, is again restored to the atmosphere. From the ammonia of the atmosphere plants derive their proximate nitrogenous constituents. Urea as a source of ammonia may be of importance as an ingredient in manures; it is especially abundant in the dung of birds, all the excrements, including the urine, being evacuated together by birds; this dung is, with the exception of that of serpents, (which is almost pure urate of ammonia,) richer in uric acid than that of any other animal.

Having somewhat diverged from the direct purpose of the present Lecture, I shall now present you with a few short and comprehensive axioms, the condensed results of our examinations and discussions respecting manures and the nutrition of plants in general.

A. ALL PLANTS REQUIRE FOR THEIR PERFECT DEVELOPMENT CERTAIN CONSTITUENTS OF THE SOIL, WITHOUT WHICH THEIR FULL GROWTH IS IMPOSSIBLE.

B. ALL THE ALIMENTS OF MAN AND OF ANIMALS ARE DERIVED EITHER DIRECTLY OR INDIRECTLY FROM THE VEGETABLE KINGDOM.

C. THE EXCREMENTS OF MAN AND ANIMALS (INCLUDING THE URINE) CONTAIN ALL THE MINERAL CONSTITUENTS OF THE PLANTS WHICH HAVE SERVED, EITHER DIRECTLY OR INDIRECTLY, FOR THE FOOD OF MAN AND ANIMALS.

D. BY RESTORING TO THE SOIL THE EXCREMENTS AND URINE OF MAN AND ANIMALS, THOSE INGREDIENTS ARE RESTORED TO THE SOIL WHICH THE CROPS HAVE REMOVED.

E. THE URINE OF MAN AND ANIMALS CONTAINS A CONSIDERABLE AMOUNT OF NITROGENOUS SUBSTANCES, THE DECOMPOSITION OF WHICH GIVES RISE TO THE FORMATION OF AMMONIA.

F. IT IS FROM AMMONIA THAT PLANTS DERIVE THE NITROGEN OF THEIR NITROGENOUS CONSTITUENTS.

These axioms, which I consider indisputable, explain at once the efficacy of manures composed of animal excrements and urine. Without the presence of the phosphates no plant can produce perfect seeds, and we therefore see the importance of restoring to the soil those salts which the crops have removed. The cereals are cultivated chiefly for their grain, which serves for the food of man, and it is, therefore, obvious that human excrements being richer in phosphates than those of any animal, must be particularly efficacious as a manure for the cereals,—whilst the dung of the horse and the cow are far inferior. We will now proceed to a more especial consideration of the various kinds of manure, and the forms under which animal substances are employed for manuring.

DUNG.

In estimating the value of *dung* as manure, we must consider that it consists

chiefly of the fæces of animals, mixed with very little urine, the quantity of the latter varying with the mode of collecting the dung. The nitrogenous constituents of dung amount to nothing in comparison with those of urine, and may be altogether disregarded in estimating its value as a manure. The efficacy of dung as a manure depends mainly upon the phosphates which it contains. This is shown by the facts, that fresh dung is rarely employed as manure, but is permitted to pass into a more or less perfect state of decomposition, and it is then found rather to have increased than lessened in value. In the process of decomposition it evolves considerable quantities of carbonic acid and ammonia, which escape into the atmosphere; if, therefore, after this process, its useful properties as manure be increased, it is obvious that these properties depend neither upon its carbonaceous nor nitrogenous constituents. If we refer its value as manure to its amount of phosphates, the matter is explained very simply; a larger amount of the mineral constituents of the dung are separated during the putrefaction, and rendered immediately capable of being assimilated by the plants, whilst, from fresh dung, the separation of these salts proceeding slowly after its application to the soil, its action as a manure is retarded. The per centage amount of salts in putrid dung must, of course, be proportionally greater, inasmuch as the escape of carbonic acid and ammonia into the atmosphere must necessarily diminish the bulk of the whole mass.

POUDRETTE.

Upon the Continent, in the vicinity of many large towns, where more fæces are produced than can be employed as manure in the immediate neighborhood, means are employed to reduce them into the least possible bulk, and to make them perfectly dry and portable, in order to facilitate their carriage to more distant ports, and to render them less offensive. For this purpose, the excrements are removed from the receptacles appropriated to them in the houses, and placed in deep pits, where they undergo the process of putrefaction, and finally become perfectly dry, and are then sold as manure; or another process is had recourse to —the excrements, whilst still moist, are mixed with quick-lime, and spread out in layers to dry. The latter is the more speedy method of accomplishing the purpose. The dry and inodorous mass thus produced is called *Poudrette*.

In examining closely the chemical processes which take place in these two methods of manufacturing poudrette, we perceive that a more or less complete destruction of the organic constituents of the excrement ensues; all the volatile products of decomposition, and especially the carbonic acid and ammonia, are expelled. The original amount of nitrogen in the fæces is in the first method reduced to a minimum; and, in the case of the employment of lime, it disappears altogether. The salts contained in the fæces remain; and it is exclusively to their presence, and more especially to that of the phosphates, that the well-known fertilising effect of poudrette must be attributed. This affords us a very satisfactory proof that the value of dung as manure does not depend upon its nitrogenous organic constituents.

BONE MANURE.

The bones of animals and of man consists of an animal substance termed *gelatine*, and certain inorganic matters. The gelatine of bones, as you well know, may be employed in the manufacture of glue; the other parts of bones, which remain behind after the bones are burned, are the inorganic salts: these exist in such a preponderating proportion as to cause the calcined bone to retain its original form. A bone which has undergone the process of calcination differs from bone in its original state only in being deprived of gelatine; it is white, of less weight, brittle, and easily reduced to powder. The average amount of organic substance contained in the bones of the mammalia and of man may be assumed to be 32 to 33 per cent.—this organic matter contains somewhat more than 5 per cent. of nitrogen—whilst the remaining 67 or 68 per cent. of inorganic matters consist principally of phosphates (52 to 57 per cent.)

The following analyses of bones are from Berzelius:

	Human Bones.	Bones of an Ox.
Animal matter (gelatine)	33·30	33·30
Soda, with Common Salt	1·20	2·45
Carbonate of Lime	11·30	3·85
Phosphate of Lime	51·04	55.45
Fluoride of Calcium (?)	2·00	2·90
Phosphate of Magnesia	1·16	2·05
	100·00	100·00

It might be supposed that the nitrogen contained in the gelatine of bones imparts to them their power of fertilising the soil. Experience has, however, proved that bones calcined, and thus entirely deprived of their gelatine, act more advantageously upon the soil than bones in their natural state. The presence of the nitrogenous organic constituent of the bones, therefore, must be considered to act as an obstacle to the rapid manifestation of their fertilising influence. The phosphates of bones, as we have seen to be the case with humus, can only become capable of being assimilated by plants after the destruction of the organic substance by decay or putrefaction. This destructive process may be exceedingly protracted in bones, and may make their application as manure, in their uncalcined state, utterly inadmissible for the purpose of manure.

OTHER ANIMAL SUBSTANCES AS MANURES.

In certain localities, where peculiar circumstances create a supply of animal substances which cannot be employed for any other more important purpose, these are used as manure. Thus, wool, rags, hair, horn, and other substances, are successfully used as manure; but this is not opposed to our assertion, that the phosphates are the chief cause of the fertilising effects of animal matters. In certain parts of Southern Russia, the wool and the tallow only of sheep are articles of commerce; the flesh is applied as manure. As civilization advances, and greater facilities are afforded for intercourse between remote places, more advantageous applications for such substances will be found, and they will cease to be used as manures.

It is a common practice in many parts of England, bordering on the sea, to take advantage of any remarkable abundance of shell-fish, or of fish which appear at certain seasons, particularly sprats, to employ them as manure. Nay, vessels have been sent to the Shetland Islands for cargoes of seals for the same purpose. These facts must be considered highly interesting, inasmuch as they are a beginning of an attempt to recover from the ocean, and to restore to the land, the immense amount of phosphates which continually pass from the land into the sea.

If you consider that the total amount of the phosphates is limited, and that in numberless places it is impossible to prevent the excrements of man and of animals from being carried away by water, and so finally to reach the sea, which must, in the long run, tend to exhaust the land of these salts, it will be obvious that we shall, in the end, be obliged to seek for means to derive these salts again from the ocean. I doubt not that should this want be ever generally felt, we might resort to more advantageous methods for the attainment of the purpose than have been thought of hitherto.

This is another proof of that ceaseless circulation of matter, to which I have before had occasion to call your attention with respect to the salts and earths of the soil. Human necessities, the incessant claims of our soil for cultivation, may compel us to seek for means to accelerate this circulation of matter. From time immemorial, such a circulation of the phosphates and other mineral constituents of plants, has existed on a small scale, since, with every aquatic animal and fish consumed by man or animals, phosphates and other salts are removed from the water and finally restored to the soil in the excrements of the consumer.

The following table may serve to give some notion of the amount of the phosphates to be derived from this source:

The bones of the Pike contain	55	per cent.	of phosphates.
" of the Cod-fish	"	50	"	"
" of the Shark	"	33	"	"
" teeth of the Shark	"	53	"	"
Shells of the Crustaceæ (Lobsters, Crabs, &c.)		5·7	"	"
Crabs' claws	"	14	"	"
Oyster shells	"	1·2	"	"

It belongs to this place to mention as animal manure, the refuse of the manufacture of glue, especially that of bones. In this manufacture bones are treated with hydraulic acid, which dissolves out all their inorganic constituents, leaving the gelatine behind. This hydraulic solution of the saline constituents of bones, may certainly be advantageously employed as a manure. At present, it is for the most part thrown away as useless, and thus hundreds of tons weight of phosphates are lost to agriculture. Experiments with this solution, tending to show how far it might be employed to supersede bone-dust, would certainly be of the greatest importance.

No better illustration can be found of the vast importance of a supply of phosphates to agriculture, than is furnished by the importation of bones into England from Germany and other parts. Even the battle-fields of the Continent have been ransacked, and the bones of warriors and their horses, mixed with the bones of cattle and sheep, and the refuse of the great towns and villages, have served to fertilise the soil of England, exhausted by her vast population with their luxurious habits and commercial restlessness.

URINE.

The chemical constitution of urine, of which I have already treated, has shown us that it contains salts which impart to it the property of fertilising the soil. But we also saw that urine invariably contains no inconsiderable amount of organic nitrogenous substances, the decomposition of which gives rise to the formation of ammonia; that is, of that substance which, as we know, is alone the source of the nitrogenous proximate constituents of plants. The question therefore arises, whether we are to ascribe the known value of urine as a manure to its nitrogenous constituents, or solely and exclusively to its amount of salts, and therefore chiefly to its phosphates.

In the first place, you must recollect that the analyses we have given of urine, refer only to it in its fresh state; and on the other hand, that it is usually employed as a manure in a putrid state. Now, if you consider that during the putrefaction of urine its nitrogenous constituents, such as urea and uric acid, are transformed into carbonate of ammonia, a volatile substance, which escapes into the atmosphere, and that thus its original amount of these nitrogenous constituents becomes materially diminished, or that they even disappear altogether, you will easily conceive that the above analyses cannot guide us in determining this point.

Practical experience has distinctly and positively proved the fertilising effect of *putrid* urine; we may therefore confidently assert that the value of *putrid* urine as a manure is solely attributable to its amount of salts.

It is, however, worth while to endeavor to prevent the carbonate of ammonia, formed by the decomposition of the nitrogenous constituents of fresh urine, from escaping into the atmosphere, by converting its ammonia into a non-volatile form, in which it may be incorporated into the soil. The chemical compounds which ammonia forms with sulphuric acid, or with hydraulic acid, are non-volatile. In order, therefore, to prevent the ammonia escaping into the atmosphere in the form of carbonate of ammonia, we need merely add to fresh urine, some of either of those acids, and sulphate or hydrochlorate of ammonia will be formed.

The following facts prove that these salts of ammonia exercise a fertilising influence upon the soil.

From a meadow which had not been manured, 8000 lbs. of hay were obtained.

The same surface, after the application of hydrochlorate of ammonia, yielded 11,432 lbs. of hay; that is, 3432 lbs. more.

And after the use of sulphate of ammonia as manure, 10,466 lbs., being 2466 more than when unmanured.

And after the application of nitrate of ammonia, 11,200 lbs., being 3200 lbs. more.

GUANO.

By referring to the table I have already given of the analyses of Guano, you will see that this substance is likewise rich in phosphates, the one kind containing 25, the other 23 per cent. The other salts present in Guano must certainly increase its fertilising effects. It has been tried and found to be a very successful manure. We regret that its high price should limit its use.

MANURING WITH SALTS OF AMMONIA.

Although this may be deemed more properly to belong to our next Lecture, when we shall have to treat of animal manures, yet the subject is so closely connected with the question of the action of nitrogenous substances, that it seems rather advisable to discuss it here.

In the ninth Lecture, I think I proved to you that the ammonia of the atmosphere is indispensable to the formation of the nitrogenous constituents of plants in general; and at the same time, that neither the free nitrogen of atmospheric air, nor the nitric acid occurring here and there in the soil, can be considered the source of nitrogen for plants. Now, we have no reason whatever to suppose that the cultivation of plants changes the fundamental laws of their nutrition. We must, therefore, consider that ammonia is solely and exclusively the source of the nitrogen employed for the formation of the nitrogenous constituents of the cultivated plants. This assumption is supported by all practical experience. All nitrogenous substances employed as manure undergo, as is well known, decay and putrefaction, that is, chemical processes which give rise to the conversion of their nitrogen into ammonia. Hence it is easily conceivable, that such substances, when decaying in a soil upon which cultivated plants grow, may supply a larger amount of ammonia to them than could be done by the atmosphere; and it may be readily understood how an ammoniacal salt may have the same effect. Admitting that this is the case, you will at once understand how important it is, that nitrogenous substances should not be left to decay in the open air, so as to allow a large amount of the ammonia formed to escape, and how advantageous it must prove to fix this ammonia by converting it into a non-volatile salt, which may be incorporated with the soil. We have seen how this may be done with urine, and the same method may be applicable in certain cases with other nitrogenous substances.

Before taking leave of this subject, I think it will be advisable to offer a few remarks upon certain experiments which have been adduced to prove that nitric acid may participate in the nutrition of plants by supplying nitrogen to form their nitrogenous constituents.

The following table exhibits the results of these experiments :—

Kind of manure employed.	Am't of manure employ'd on a surface of four acres—1 Hectare.	Amount of hay reaped.	Surplus am't of hay reaped upon applying manure.
1. No manure		8,000 lbs.	
2. Hydrochlorate of Ammonia	532 lbs.	11,432 "	3,432 lbs.
3. Sulphate of Ammonia	532 "	10,466 "	2,466 "
4. Nitrate of Ammonia	532 "	11,200 "	3,200 "
5. Nitrate of Soda	532 "	11,446 "	3,446 "
6. Ammoniacal Water	5,400 litres.*	12,600 "	4,600 "
7. Gelatinous fluid obtained by boiling bones	21,666 "	12,986 "	4,986 "
8. Horse's Urine	21,666 "	12,480 "	4,480 "
9. Flemish Manure	21,666 "	14,886 "	6,886 "

The ammoniacal water of 6 was derived from a gas work, its ammonia had been converted into hydrochlorate by mixing it with the acid which had been employed to separate the gelatine from bones, and which consequently contained all the phosphates of the bones.

The gelatinous solution, No. 7, was obtained by boiling bones in order to extract their fat; it contained 2½ per cent. of gelatine, and a considerable amount of phosphates.

The horse's urine, No. 8, of course contained phosphates.

The Flemish manure, No. 9, consisted of human excrements and urine, with other refuse thus collected in households, and was, therefore, exceedingly rich in phosphates.

These four experiments, therefore, 6, 7, 8 and 9, cannot serve us in judging of the efficacy of nitrogenous manures, since salts, especially phosphates, were likewise present in these cases, and since we know that the ashes of good meadow

* A litre is a measure containing somewhat above a pound and half of water.

hay contain 20 per cent. of phosphates: we must, therefore, confine our examination to experiments 2, 3, 4, 5.

Bearing in mind that ammonia contains 82 per cent. of nitrogen, and nitric acid 26 per cent. of this element, we shall find, upon calculation, that the salts applied as manure in these four instances contained the following quantities of nitrogen:—

THE SULPHATE OF AMMONIA CONTAINED 149 POUNDS OF NITROGEN IN THE FORM OF AMMONIA.

THE HYDROCHLORATE OF AMMONIA CONTAINED 149 POUNDS OF NITROGEN.

THE NITRATE OF AMMONIA CONTAINED 229 POUNDS OF NITROGEN—138·5 IN THE FORM OF AMMONIA, 90·5 IN THE FORM OF NITRIC ACID.

THE NITRATE OF SODA CONTAINED 85 POUNDS OF NITROGEN IN THE FORM OF NITRIC ACID.

The following table shows, in round numbers, the surplus amount of hay obtained by the application of these manures, corresponding to the amount of nitrogen:—

lbs.				lbs.
150	of Nitrogen as	Sulphate of Ammonia	yielded a surplus of	3,400
150	"	Hydrochlorate of Ammonia	"	2,400
230	"	Nitrate of Ammonia	"	3,200
90	"	Nitrate of Soda	"	3,400

And now I would ask who would venture to assert from these numbers, that the nitrogen of the nitric acid must have participated in producing the surplus amount of hay? They do not even show us the relation in which the total amount of nitrogen contained in the salts applied as manure, stands to the resulting amount of the harvest. For we see on the one hand that the nitrate of soda, which contains but a scanty proportion of nitrogen, yielded as high an amount of hay as the sulphate of ammonia, which is far richer in nitrogen; and on the other hand, the nitrate of ammonia, a substance exceedingly rich in nitrogen, yielded a less amount of hay than the nitrate of soda or the sulphate of ammonia, which latter substance, although richer in nitrogen than the nitrate of soda, contains no nitric acid. Thus we may fairly set aside these and similar experiments, inasmuch as they are inappropriate, and prove nothing whatever.

LECTURE XVII.

MINERAL MANURES.

Lime....Sulphuric Acid....Gypsum....Various Salts....Marl....Irrigation.

GENTLEMEN:—The discovery of the fact that various substances, belonging to the mineral kingdom, are capable of promoting the growth of the cultivated plants, was probably, like most similar discoveries, owing to accident. To such mineral substances, the term *stimulating manure* has been applied, in contradistinction to manures derived from the animal and vegetable kingdoms, which are called *nutritive manures.* These terms were applied, and this distinction was made, in total ignorance of the manner in which mineral substances promote the growth of plants, the humus theory then prevalent did not admit them to be considered *nutritive.*

I shall endeavor, in the present Lecture, to explain to you in what way those mineral substances which are generally employed as manures, act upon the soil, and minister to the purposes of cultivation; and for this purpose, I shall treat the properties of mineral manures *seriatim.*

LIME.

Lime, in its calcined state termed *quick-lime,* is undoubtedly most frequently used in agriculture with the view to directly fertilising the soil. It can, however, answer this purpose only to a very slight extent, or in a few rare instances, since cultivated plants, in most cases, will find as much lime in the soil as they

require for their growth and perfection, owing to the exceedingly profuse diffusion of lime upon the surface of the earth; so that an artificial supply of this substance would appear to be, in this respect, perfectly superfluous. If, nevertheless, we see that lime exercises a favorable influence on vegetation, the cause of this must be sought in some other property of lime; and this property is its inducing or facilitating the supply of other mineral ingredients necessary to the growth of plants.

In the first place, I must recal to your recollection a fact I have already explained to you in a former Lecture—namely, that quick-lime greatly accelerates the decomposition of humus, whether of animal or vegetable origin, inducing a more speedy liberation of its salts than would otherwise take place. This is the reason quick-lime has proved so advantageous in the cultivation of bogs: the lime not only accelerates the decomposition of the humus, but it may be said altogether to be the cause of the decay of humus, which, as it exists in peat, is scarcely by itself undergoing the process at all. It thus liberates a number of salts, which may serve for the development of cultivated plants. The favorable action of lime upon such soils has been long known, but it was without investigation ascribed to the formation of the humate of lime capable of nourishing the plants. In the Sixth Lecture I have proved the erroneousness of such an opinion, and nothing more need be added upon the subject.

Quick-lime also exerts a favorable influence upon the soil when the latter contains silicates which it is desirable to disintegrate more speedily than would be accomplished by the agency of the atmosphere; thus liberating a greater amount of soluble silica and alkaline salts in a given time. For the most part, therefore, we do not consider that lime itself can be employed directly to supply the plants with nourishment, but that its usefulness is rather confined to rendering other mineral ingredients capable of being assimilated by plants.

When there is neither humus in the soil, nor undecomposed silicates, the application of lime as manure will be useless.

SULPHURIC ACID.

The attention of agriculturists has of late been called to the properties of sulphuric acid as a manure. In order to have a correct notion of the manner in which this acid acts as a manure, you must know, in the first place, that it is an exceedingly powerful acid having a great tendency to combine with bases. By reason of this tendency it decomposes the salts of weaker acids, such as carbonic acid, hydrochloric acid, nitric acid, &c., and expels these acids. When, therefore, sulphuric acid is brought into contact with ordinary arable soil, it decomposes all the salts present, transforming them into sulphates. As carbonate of lime is present in most soils, this is decomposed by the sulphuric acid, and sulphate of lime—gypsum—is formed. I do not believe that there is any ground whatever for ascribing the action of sulphuric acid upon the soil to anything but the formation of gypsum; and all practical experience of its use as manure decidedly supports this opinion.

The original French method of employing sulphuric acid prescribes its application in a very dilute state, 1 part of the acid to 1,000 parts of water. Some agriculturists have attempted to fix the sulphuric acid and to apply it in a dry state. We read of experiments made with this view, in the following manner. Two pounds of sulphuric acid diluted with 40 pounds of water, were poured, by means of a watering pot, over a thick bed of coal and wood ashes, and the ashes were then thrown up into a heap and allowed to dry. The experimenter tells us, the moistening of the ashes with the acid gave rise to the liberation of carbonic acid, the mass becoming considerably heated. Now this fixation of sulphuric acid is nothing more nor less than the formation of gypsum, the carbonate of lime contained in the ashes being decomposed by the acid, and the latter combining with the lime; when, therefore, this mass was applied to the soil, it proved especially efficacious in promoting the growth of certain plants which require sulphate of lime, such as saintfoin, lucerne, peas, &c.

Another method of applying sulphuric acid has been recommended. It consists in drenching the seeds previously to sowing, with dilute sulphuric acid (1 part to 200 parts of water) for 12 hours, and then strewing them with a mixture of finely-powdered calcined lime and ashes, working them together until

they no longer adhere, and then immediately sowing them. Here again we have the formation of gypsum, which is especially favorable to the growth and developement of grass, clover, &c.

From all the experience with which we are acquainted, we must conclude that the fertilising effect of sulphuric acid is exclusively owing to the formation of gypsum, and, therefore, that where there is no lime present in the soil, the application of sulphuric acid will prove useless.

GYPSUM.

The action of gypsum as a manure is two-fold. In the first place, it serves directly for the nourishment of some cultivated plants; and, secondly, it fixes and retains in the soil certain soluble substances, which are necessary to the nutrition and growth of plants. We have just seen that the favorable effect of sulphuric acid arises exclusively from the formation of gypsum, we need, therefore, say nothing more respecting gypsum as a direct nutriment for plants—except to remark that it is always better to employ gypsum rather than sulphuric acid, as it is cheaper and more manageable. The sulphuric acid of commerce contains 80 per cent. of dry acid, and gypsum 60 per cent., yet the difference in price is in favor of the use of gypsum.

With respect to the second mode of action of gypsum, this depends upon its property of transforming into sulphate of ammonia, the carbonate of ammonia, supplied to the soil in rain-water, or by the decomposition of animal substances. Thus, this volatile substance is converted into a non-volatile salt, and remains in the soil to be assimilated by the plants. You may easily convince yourselves by experiment, that a double decomposition occurs when carbonate of ammonia is mixed with sulphate of lime, and that the result is the formation of sulphate of ammonia and carbonate of lime.

I will here relate to you an experiment, to show you how this process takes place in employing gypsum as a manure.

A small plot of garden ground was manured with fresh horse-dung, and then sowed with peas and beans—the surface was then covered with a thin layer of uncalcined gypsum. The ground was protected from rain, and watered in dry weather. All the beans and peas grew up with extraordinary rapidity and luxuriance. Before commencing the experiment, the soil, as well as the gypsum, were accurately tested, and exhibited not the slightest trace of a carbonate. But when, after the lapse of three weeks, the gypsum was removed from the surface and tested, the greater part of it was found to have become transformed into carbonate of lime; the whole soil to the depth of six inches effervesced strongly with acids. The soil was lixiviated with cold water, the fluid filtered, and after evaporation a considerable amount of sulphate of ammonia remained. The very slight solubility of gypsum in water, and the slowness of its decomposition by carbonate of ammonia, explain the favorable action of gypsum as manure, and the reason why its effects are not transitory but remain for years.

In conclusion I must remark, that the application of gypsum to the soil, when there already is sufficient amount of this substance present, will, of course, be useless; nor can we expect gypsum to restore the fertility of a soil deficient in phosphates or silicates, and which therefore require a supply of these salts.

VARIOUS SALTS EMPLOYED AS MANURES.

The refuse of salt works, left after the production of common culinary salt, is frequently termed *manuring salts;* this refuse consists chiefly of a mixture of the sulphates of various bases, with a predominating proportion of sulphate of lime. The remarks which I have made with respect to gypsum are, therefore, greatly applicable to this kind of manure. The term *manuring salts* is, moreover, applied to all substances having a saline taste, and which, therefore, contain certain soluble salts. I shall confine my attention to the nitrate of soda, nitrate of ammonia, and hydrochrolate of ammonia, since experiments have been made with these salts, which prove positively that they are capable of exercising a fertilising influence on the soil. And let me refer you to what I stated in my last Lecture, respecting the manuring with ammoniacal salt. We saw that the application of these salts to meadows certainly increased their produce; the question now is, to what are we to ascribe this fertilising property?

My own impression is, that we must ascribe it simply to the *bases* of the salts—at present we cannot say precisely what part the acid takes in the effect. In order to arrive at a correct conclusion upon this subject, it is necessary to have accurate analyses of the productions of meadows fertilised by nitrate of soda and other salts.

I may add one observation. The prices of salts employed as manures, nitrate of soda, nitrate of ammonia, hydrochlorate of ammonia, &c., are such, that the surplus produce of the hay obtained by their application as manures, as appears in the experiments detailed in my last Lecture, although certainly not inconsiderable, yet is insufficient to repay the farmer for the necessary outlay.

Whenever the agriculturist has the opportunity of obtaining the ammoniacal liquor of gas works, it may be worth his while to fix the ammonia by means of sulphuric or muriatic acid. And whenever the saline refuse of any manufacture may be at hand, and can be obtained cheaply, it should be examined for its manuring properties; there are, doubtless, many such at present wasted, which might be advantageously employed as manure.

By mixing stable urine with hydrochloric acid, muriate of ammonia, or sal-ammoniac, will be formed, and the ammonia thus prevented from escaping into the atmosphere.

MARL.

Marl is a mixture of carbonate of lime and alumina; it is designated *clay* marl, or *lime* marl, as the one or the other of these substances predominates in its composition. Marl usually contains in admixture with its proper constituents, many others, such as sand, sulphate of lime, felspar, undecomposed but minutely divided, sulphuret of iron, fragments of shells, peroxide of iron, oxide of manganese, and carbonaceous matters resembling humus. The latter substance varying much in proportion in various marls, causes the variations in their color. Marl also contains, invariably, small quantities of salts of potass and soda, and is rarely entirely free from phosphates. Marl, as usually found, has the appearance of soft stone, but when exposed to the atmosphere it effloresces, that is, it crumbles into a powder and becomes a very fertile soil, in which the most various plants grow and flourish. It is this circumstance, doubtless, which has led to its employment as manure, and certainly in many cases it has proved successful.

The very complex composition of marl renders it difficult to give any general opinion as to the manner in which it acts as manure; the most conflicting statements, therefore, are made with respect to its uses. So much, however, is deducible from all experience, that the mere application of marl to an exhausted soil is of no use whatever, unless it is carried on the field in such quantities as to constitute a new soil, covering the whole surface to the depth of a foot. In cases where marl is employed together with other manures, its action consists chiefly, if not altogether, in mechanically improving the condition of the soil. In a chemical point of view, marl is not of any value as a manure, except where the soil requires a supply of lime; and then the direct application of lime is better, and far less expensive. The other mineral constituents of marl are far too inconsiderable in amount to be reckoned upon.

IRRIGATION.

There is scarcely a more fertile country in the world than Egypt, and its fertility has existed undiminished for thousands of years. The cause of this fertility is a process of manuring unrivalled and unequalled in magnitude, and compared to which, all the works and labors of man appear mere child's play; for Nature herself, in her omnipotence, condescends to manure the fields of Egypt, employing the waters of the Nile to convey the necessary materials upon the soil. The degradation of granitic mountains in Abyssinia, furnishes an immense amount of the most fertile soil, which is carried off by the rains periodically, and by the subsequent inundations of the river is deposited in the lower parts of Egypt; and spread over the cultivated fields in the form of mud.

In my Fifth Lecture, I explained to you that the disintegration of rocky masses, gives rise to the formation of various salts, but especially soluble alkaline carbonates, and silicic acid. We, therefore, find that the cultivated plants of Egypt are such as require these salts for their successful growth; all the various kinds

of cereals, the sugar-cane, cotton, &c. The materials necessary for the development of these plants are partly brought and deposited by the waters of the Nile in a state fit for immediate absorption by the plants, and partly left in so minutely divided a state, as very readily to undergo the necessary decomposition: being left in a very moist state, in so hot a climate, all the organic matters mixed with the minerals undergo a rapid decay and putrefaction, and supply abundance of carbonic acid to act upon the minutely comminuted minerals. Hence, we perceive that whatever other advantages may accrue to the soil of Egypt from the inundations of the Nile, it certainly supplies the inorganic constituents of plants; and especially of the silica plants.

Now, precisely the same process occurs on a small scale in the inundations of brooks and rivers; the mud which is left behind the mineral ingredients of plants, especially silica and the silicates.

It is quite indifferent whether this overflowing of water be a consequence of heavy rains, or is effected artificially. This artificial overflowing of meadows is very frequently employed in Germany; and in the plains of Lombardy it is practised on a very extensive scale in rice and maize-fields. It is accomplished in two ways, according to the circumstances of the locality; sometimes the land is overflowed with water which is allowed to evaporate, or when the land forms an inclined plane, a continuous very weak stream is made to run over it uniformly; and in order to ensure its depositing all the matter which it holds in mechanical suspension, small dikes are erected at short distances, which check the stream, and allow the water to deposit its contents ere it overflows them.

In all these cases the effect is a supply of mineral ingredients to the soil which may serve as the nourishment of the plants grown upon it; chemically pure water would not, therefore, exercise any influence as manure; its application would be useful only where the necessary salts and earths exist in the soil destitute of water; in such cases it would render the soil fertile by acting as a solvent, which is a merely mechanical effect.

To recapitulate in a few words the substance of this Lecture upon manures, we have seen that vegetable and animal substances act upon the soil as manures chiefly by supplying it with the mineral ingredients of plants, that is, that they act precisely in the same manner as mineral manure. Hence, we may safely infer that whilst organic substances may be employed in all cases where they are cheaply and easily procured, but that wherever their use is fraught with difficulty or expense, saline and mineral substances may be advantageously substituted for them.

LECTURE XVIII.

CONCLUSION.

GENTLEMEN:—Having now arrived at the conclusion of these Lectures, I deem it advisable to glance at a few points which we have already discussed, but which yet claim your particular attention, in order to excite your interest, and to stimulate you to study them still further as opportunity and leisure may serve.

You will not, I think, call in question the assertion, that the practical farmer ought to know what are the wants of plants generally, and especially of the plants he cultivates. Now we have examined minutely into the material and essential wants of cultivated plants, and we have arrived at the conclusion that humus, whether of animal or vegetable origin, does not belong to the essential wants of plants; but, on the other hand, we have found that the constituents of the atmosphere, together with certain solid but soluble ingredients, derived from the soil, are sufficient to supply plants with all the nourishment they need for their existence and perfect development.

With respect to those constituents which plants derive from the atmosphere, we conclude from its constant contact with the entire surface of plants, and from its maintaining invariably the equilibrium of its constitution, that the atmo-

sphere always furnishes a sufficient supply, so that there is no necessity whatever that we should artificially provide any of them for the use of plants.

It is altogether a different matter with respect to that kind of nourishment which plants derive from the soil, that is, their mineral constituents, the saline and earthy matters left as ashes after the combustion of vegetable substances; they do not exist in exhaustless abundance, nor do they accumulate in the soil in the same ratio as the cultivated plants require. It is, therefore, indispensable that an artificial supply of such substances should be carried on to the soil, whence a large amount has been taken by the preceding crops. This constitutes the necessity of manuring.

Further, we have also seen the different species of the plants cultivated require from the soil different mineral ingredients, and, therefore, a rational system of manuring is only possible when the especial wants of every species of plant are fully known, and the constitution of the soil in each special locality also is taken into consideration. These circumstances must, therefore, determine the fertilising nature of any kind of manure. Thus, for example, Guano acts very advantageously on a soil containing a sufficient amount of duly disintegrated silicates. It produces no effect upon the growth of ornamental plants requiring no phosphates; but to conclude from this that it is useless as manure, would be as erroneous as it would be to conclude that a given nutritive substance would support no animal whatever, because it is found not adequate to the support of some one animal.

I trust, Gentlemen, that I shall leave you with a conviction on your minds of the paramount importance of the mineral constituents of plants, and of the necessity for the attention of the farmer being directed to them. In future, they must occupy the same place in theory and practice which humus has hitherto usurped. I do not mean to assert, that the immediate result of our new views will be a complete overthrow of the method of manuring which has been long pursued—namely, with vegetable and animal humus; but so much is certain, that these views will greatly benefit the farmer, by showing him how he may supply the deficiency of his animal and vegetable manures with mineral substances. When the conviction of these truths is once established, it will enable the farmer to sell his straw—and in many localities this can be done with great advantage—and to replace the ingredients which have been taken from the soil in the straw, by purchasing the necessary mineral substances from the manufacturer.

When the chemist has succeeded in discovering some economic use for the carbon and nitrogen of organic substances now employed only as manure, these substances will find their way into the manufactory; and the refuse, carbonaceous, nitrogenous, and mineral constituents, will be issued thence again to the agriculturist as the manure for his fields.

To the science of Chemistry, the agriculturist may confidently look for the future improvement of his art. There is still doubtless much to be done in the way of pure scientific investigation, as well as in applying our knowledge in practice, before Agricultural Chemistry can be perfect; but it only requires the hearty coöperation of the scientific chemist and the practical agriculturist to draw from it results, not only tending to enrich individuals, to support and augment the wealth of states, but to confer an universal and permanent benefit upon all mankind.

APPENDIX.

No. I.

It cannot be too frequently or too urgently impressed upon the Agriculturist, that the application of Chemistry to the improvement of his art is far too recent to have brought forth all its fruits. Chemistry itself, in its application to organic nature—in its investigations into the composition and functions of plants and animals, is in a state of progress, not of perfection. There must still be, therefore, conflicting opinions; and facts, announced as discoveries, must be expected to be refuted, and replaced by better, as the science advances. Nevertheless, agriculture cannot be perfected without Chemistry. How is it possible, whilst the composition of the soil, of the plants growing upon it, and of the manures supplied for their nourishment, shall all continue unknown? Laborers are wanted in this field of science! Farmers themselves must be able to find out what are the materials existing in their soil. The Chemist must ascertain what substances enter into the composition of every species of plant, and are therefore indispensable to their growth. Commercial men will soon discover the sources whence the necessary manures may be obtained in the cheapest and best form. A few words upon Guano, in addition to the text, will illustrate these remarks. The analyses there given are of South American Guano; of that brought from Africa, the following have been published, by Mr. Francis, Dr. Ure, and Mr. R. Phillips.

In 100 parts, one specimen contained:—

Ammonia	9.70
Water	27.13
Phosphates of lime, magnesia, &c.	22.32
Alkaline salts, chiefly potass, with sulphuric, phosphoric and hydrocholoric acids	7.08
Combustible organic matters—uric acid and extractive	32.89
Sand	.81
	100.00

A second specimen:—

Ammonia, chiefly combined with phosphoric acid, some carbonate	9.5
Water	28.5
Earthy phosphates	18.5
Fixed alkaline salts, chiefly potass	6.0
Combustible organic matter—three parts uric acid	37.0
Sand	.5
	100.0

A third:—

Ammoniacal salts, containing 7 1-5 of ammonia, and organic animal matter	46.0
Phosphate of lime, &c.	19.8
Fixed alkaline salts	4.2
Sand	4.0
Water	26.0
	100.0

It is a question of no small importance to the agriculturists, to which of these constituents of Guano it owes its fertilising properties. The ammonia is generally considered to be the most valuable ingredient; but the recent investigations of the German chemists seem to indicate that the presence of the earthy phosphates gives guano its chief value. Experiments, to determine this point, are needed. The farmer must remember that, in purchasing guano, he receives with every ton from five to six *cwt.* of water, from one and a half to two *cwt.* of ammonia, and about double the latter amount of the earthy phosphates. According to the principles of this work, the value of guano as a manure would be increased by mixing it with wood ashes, as the latter would supply the necessary fixed alkaline salts. So far as the ammonia is valuable, the farmer must remember that *quick lime*, mixed with the guano, would drive the ammonia off, whilst *gypsum*, *soot*, sulphuric acid, &c. would serve to render it fixed.

It is a question of relative cost, whether the farmer should purchase guano, or endeavor to supply its place by artificial mixtures. The following is a receipt for artificial guano:—

Bone dust	3 cwt.
Sulphate of ammonia	1 "
Common salt	1 "
Sulphate of soda	10 lbs.
Pearlash	10 " Mix.

He cannot be an economical farmer who would purchase guano while he allows stable urine to run to waste. In addition to the method recommended in the text, as best adapted to fix the ammonia of stables, it may be mentioned that another excellent and cheap method is to mix one pound of sulphuric acid with about twenty pounds of water, and to sprinkle this dilute acid upon saw-dust, which for this purpose may be spread lightly in suitable parts of the stable. This method is said to have been found highly beneficial to the health of cattle, and to dogs in kennel, by fixing the floating ammonia.

In order to escape from the frauds practised in the adulteration of guano, the farmer should possess the means of testing it; at least, so as to approximate to a knowledge of its composition. For this purpose, it will be sufficient to perform three simple experiments.

First. Treat 100 grains with lukewarm water, and, after shaking it for some time, filter the solution through paper; about 68 per cent. should be soluble.

Secondly. Dissolve 100 grains in strong hydrochloric acid, and, in the same way, about 94 per cent. should dissolve.

Thirdly. Place 100 grains in a stoppered retort, and adapt the retort to a receiver, in which is contained dilute hydrochloric acid, about ¼ of an ounce of the acid to 4 ounces of water. Into the retort throw 100 grains of slacked lime, and about an ounce of water; apply a gentle heat, until all the water has passed over. Evaporate the contents of the receiver to dryness, and weigh the sal-ammoniac which remains. One third of the amount very nearly expresses the amount of ammonia present in the guano. Thus, 100 grains of guano should yield about 27 grains of sal-ammoniac.

This does not furnish an absolutely exact measure of the value of the guano. There may be certain nitrogenous ingredients which escape decomposition, but these are so insignificant in amount, that for practical purposes the approximation is sufficient.

No. II.

In a recently-published paper emanating from the Giessen school it is stated that, for most purposes, a chemical examination of the Soil is best accomplished by carefully collecting all the plants growing upon it, both those cultivated and the weeds, reducing them to ashes, and subjecting these ashes to chemical analysis. In this manner all the soluble constituents of the soil may be known, and the presence or absence of alkalies, alkaline earths, and phosphates may be ascertained.

When we know the composition of the ashes of the weeds and cultivated plants, we know the soluble constituents of the soil, and we can determine for what crop it is most suitable.

In order to enable this inquiry to be pursued as extensively as the interests of agriculture require, Drs. Will and Fresenius have devised and published a method for the examination of the ashes of plants, which is as follows:—

PREPARATION OF THE ASHES.

Plants in a normal and healthy condition should be selected (unless the design be to study diseases and their causes.) All foreign matter, such as dirt, dust, &c., should be carefully removed; but the plants should not be washed, or the soluble salts will be extracted. Plants exposed to moist weather, or in a withered state, should also be rejected for the same reason.

Woods, herbs and roots, after being perfectly dried, may be burned upon a clean iron plate; leaves, fruits and seeds will be best burned in a Hessian crucible, using as fuel charcoal, amidst which the crucible should be placed somewhat obliquely. Sometimes the ashes are left perfectly white; but some seeds require a higher temperature than others to rid the ashes of charcoal, which is mixed with the phosphates: care must, however, be taken to fuse the alkaline salts, or they will prevent the perfect combustion of the charcoal. Those ashes will be burnt the whitest which are not shaken or stirred together. The ashes should afterwards, if necessary, be heated to low redness in an open platinum crucible, over a spirit-lamp, with constant stirring; then, whilst still warm, rubbed to a fine powder, and transferred to a well stopped bottle.

A qualitative analysis should first be made in order to determine to which of the following three groups the ashes belong.

A. *Ashes rich in alkaline and earthy carbonates;* woods, lichens, &c., containing salts with organic acids, yield ashes of this kind.

B. *Ashes abounding in phosphates of alkalies and earths;* as the ashes of seeds, grain, &c.

C. *Ashes rich in silica.* The grasses and straw of cereals belong to this group.

PRELIMINARY QUALITATIVE EXAMINATION OF ASHES.

A portion of the ashes being treated with concentrated hydrochloric acid, a considerable effervescence denotes them to belong to the first group.

If the ashes abound in silica, this will be left undissolved by hydrochloric acid.

In other cases concentrated hydrochloric acid dissolves the ashes of plants completely. After the separation of the silica, the acid solution is treated with acetate of ammonia, or it may be neutralised by means of caustic ammonia, free acetic acid being afterwards added. In most cases a yellowish-white gelatinous precipitate is formed, consisting of phosphate of peroxide of iron. This precipitate must be collected upon a filter, and ammonia added in excess to the clear solution, by which means a fresh precipitate will be obtained. If a red precipitate be formed, it is peroxide of iron. The solution should now be allowed to stand for some time, the air being excluded; if no precipitation takes place, the ashes contain no phosphate besides that previously separated, but if there be a white precipitate, it consists of phosphate of lime and phosphate of magnesia, more phosphoric acid being present than is combined with peroxide of iron. This completes the qualitative examination, unless the operator choose to test for fluorine, oxide of manganese, iodine, bromine, or any other substance, the presence of which may be suspected. Separate portions of ashes must be used for these purposes, as also for carbonic acid, and alkalies, in ashes belonging to the third group. The other constituents may be determined in one quantity of ashes; the silica has only to be separated once.

QUANTITATIVE EXAMINATION OF ASHES.

A. *Determination of the Quantity of Ashes in Plants.*

It is often highly desirable to ascertain the entire quantity of inorganic constituents of plants. A quantity of solid matter is annually removed from the soil in the crop, and it is necessary to repair this loss by means of manures. The weight of the crop, taken from a given surface, should therefore be well known; and rational agriculturists acquire this information with sufficient accuracy for practical purposes.

The vegetable substance under examination should be dried over a water-bath until it no longer loses weight. The quantity most convenient to employ depends upon the proportion of its inorganic constituents. Herbs and seeds, being rich in these matters, from thirty to fifty grains will be sufficient, whilst ten times that amount must be taken of woods. The combustion succeeds best in a platinum crucible, at first covered and heated gently; afterwards remove the lid and apply a stronger heat to consume all the charcoal. Those ashes which do not effervesce with acids, as the ashes of seeds, may be treated with nitric acid and again ignited, when they will be speedily rendered quite white.

B. *Analysis of Ashes rich in Carbonates and Phosphates.*

1. *Determination of the Silica, Charcoal and Sand.*—About sixty grains of the ashes, which have been found soluble in hydrochloric acid, are to be treated with concentrated acid in a matrass, held obliquely, so as to avoid any loss of fluid during the evolution of carbonic acid; a gentle heat is then applied, until it is evident that every thing is dissolved, excepting the carbonaceous and sandy particles. The whole is now carefully removed into a porcelain basin, evaporated to dryness over a water-bath, and then heated somewhat more strongly, as is usual in separating silica. The mass when cold is moistened with strong hydrochloric acid, digested for half an hour with a sufficient quantity of water, and boiled, after which the acid liquid is poured upon a stout filter which has been previously dried at 212° and weighed.

The silica will remain upon the filter, and if the ashes were not perfectly white and pure, some sand and charcoal also. The filter is washed and dried, and the substance carefully removed from it into a platinum crucible, without injury to the paper. This is easily effected if the matters be perfectly dry, the paper in most cases only retaining so much as to be slightly colored by the charcoal. The powder is now boiled for half an hour with pure potass-ley, (free silica,) by which the whole of the silica will be gradually dissolved; leaving the sand and the charcoal unacted upon. The insoluble matter is again collected on the same filter, washed, and dried at 212° until it no longer loses weight. The increase upon the weight of the dried filter is estimated as charcoal and sand.

The filtered solution, after the addition of hydrochloric acid in excess, evaporation to dryness, and treatment in the usual way, gives the amount of silica.

The acid solution originally filtered from the silica, sand and charcoal, after being well mixed, is divided into three, or more conveniently into four equal portions, one being reserved in case of misfortune with either of the other quantities. The division is best accomplished by means of an accurately graduated tube; the whole of the fluid is collected into the tube, the entire measure then representing the weight of ash experimented upon. The solution is now divided into three or four equal or known portions, the volume of each is noted, and they are distinguished by the letters *a*, *b*, *c*, and *d*.

In (*a*) the peroxide of iron, oxide of manganese and the alkaline earths are estimated.

In (*b*) the alkalies.

In (*c*) the phosphoric and sulphuric acids.

2. *Estimation of the Peroxide of Iron and of the Alkaline Earths.*—To the solution (*a*) ammonia is added until the precipitate which is thereby produced no longer entirely re-dissolves; acetate of ammonia is next added, and enough acetic acid to render the solution strongly acid. From the form and appearance of the precipitate it can easily be judged whether it still contains phosphate of lime; if this be the case, more acetic acid must be added. The yellowish-white precipitate which remains consists of phosphate of the peroxide of iron, $2\ Fe_2\ O_3 \times 3\ P\ O_5$. Its separation from the fluid is assisted by gently heating, it is then well washed upon a filter with hot water, ignited and weighed.

To the filtered solution, neutral oxalate of ammonia is added as long as a precipitate is formed, and the quantity of lime is determined in the usual manner. When it has been shown by the qualitative analysis, that besides phosphate of iron, the ash contains peroxide of iron or oxide of manganese (in which cases the presence of earthy phosphates is very rarely detected), the solution, previously to the separation of the lime, should be super-saturated with ammonia, and precipitated by means of sulphuret of ammonium; the two oxides being afterwards separated according to the known methods.

If the ashes under examination contained earthy phosphates, the solution, filtered from the oxalate of lime, will contain free acetic acid; if otherwise, there will be free ammonia; it is next somewhat concentrated, rendered ammoniacal, treated with a solution of phosphate of soda, and separated from the precipitate, which is estimated as phosphate of magnesia.

3. *Estimation of the Alkalies.*—The solution (*b*) is treated with water of barytes until it gives an alkaline reaction; it is then gently heated and filtered. By this means we get rid of all the sulphuric acid, phosphoric acid, and peroxide of iron, as well as the magnesia, and most of the lime. The precipitate is washed upon a filter as long as the liquid renders turbid a solution of nitrate of silver; the solution is next warmed, treated with caustic ammonia and carbonate of ammonia, and allowed to stand until the precipitate becomes heavy and granular. The whole is now filtered, and the solid matter is washed, after which the solution is evaporated to dryness, and the residue heated to redness in a platinum crucible, in order to expel the ammonical salts. What remains, consists of the chloride of potassium or sodium, or more generally of a mixture of the two. The weight being noted, a little water is added, which mostly leaves undissolved a trace of magnesia; this is collected on a filter, its quantity subtracted from that of the supposed alkaline chlorides, and added to that of the magnesia as previously ascertained. The quantity of potass is determined by means of chloride of platinum in the usual way; and that of the soda is calculated from that of the chloride of sodium, indicated by deducting the weight of the chloride of potassium from that of the mixed alkaline chlorides.

4. *Estimation of the Sulphuric and Phosphoric Acids.*—From the acidulous solution (*c*), the sulphuric acid is first separated by means of chloride of barium. The filtered liquid is nearly

neutralised with ammonia, acetate of ammonia is added, and then a solution of perchloride of iron, until the liquid begins to turn red, owing to the formation of acetate of iron. Care must here be taken that sufficient acetate of ammonia be added to convert the whole of the chlorine of the perchloride into sal-ammoniac. The solution is now boiled until it becomes colorless, all the iron being then precipitated. The precipitate, after being washed with hot water, consists of phosphate of iron and a quantity of basic acetate of iron. It is dried, ignited in a platinum crucible, treated with a few drops of nitric acid, reignited and weighed. It is next digested with concentrated hydrochloric acid, which speedily dissolves it. The solution is diluted with hot water mixed with tartaric acid, and ammonia is added until the yellowish-white precipitate which is at first formed, disappears. A clear solution, but of a dingy green color, is thus obtained, from which the iron is precipitated by means of sulphuret of ammonium. The precipitate and supernatant fluid are digested together in the water-bath until the latter loses its green tinge, and assumes a clear yellow color, resembling that of the sulphuret of ammonium. It is now rapidly filtered, access of air being excluded, and the precipitate is then washed with hot water containing a little sulphuret of ammonium, until a drop of the filtered liquid, dried upon a platinum spatula and ignited, no longer manifests an acid reäction. The sulphuret of iron is dissolved from the filter by means of hot and dilute hydrochloric acid, the solution is boiled, treated with a few drops of nitric acid to peroxidise the iron, and ammonia is then added in excess. The precipitate is pure peroxide of iron, the weight of which, deducted from that of the basic phosphate, gives the quantity of phosphoric acid. It is essential that the perchloride of iron used in this experiment should be quite free from sulphuric acid.

5. *Estimation of the Chlorine.*—A fresh portion of ashes (about fifteen grains) is weighed out, exhausted by means of hot water, slightly acidulated with nitric acid, and the solution precipitated with nitrate of silver.—If the ashes contain appreciable quantities of iodine of bromine, these bodies will be found in the precipitated silver-salt; for their quantitative estimation, however, a larger portion of ash must be employed.

6. *Estimation of the Carbonic Acid.*—The quantity of carbonic acid is represented by the loss sustained on treating a known weight of ashes with an acid; and we have elsewhere described the most convenient method and apparatus for the experiment.

C. *Analysis of Ashes abounding in Silica.*—These ashes are only partially soluble in acids; their alkalies must therefore be determined in a separate portion.

The chlorine and carbonic acid are determined in the same manner as with ashes soluble in acids; but it must be remembered that the alkaline chlorides undergo a partial decomposition, when ignited with silica and carbon.

1. *Estimation of the Silica, &c.*—A concentrated solution of pure potass or soda is poured upon about 60 grains of the ashes, and evaporated to dryness in a platinum or silver dish. The silica compounds are thus dissolved—the heat should not be so great as to fuse the mass:—dilute hydrochloric acid is then poured on the dry mass, and evaporated, and the silica determined in the manner already described. The acid solution, filtered from the insoluble matter, is divided into two parts; one is employed for the determination of the sulphuric acid and phosphoric acid, the other for that of peroxide of iron and of the alkaline earths, by the methods detailed above.

2. *Estimation of the Alkalies.*—A second portion, say 50 grains, of the ashes is ignited in a platinum or silver crucible, with four times its weight of hydrate of barytes; the acid solution which remains after separating the silica, is precipitated successively with barytes water and carbonate of ammonia, the alkalies being then obtained in the state of chlorides.

GLOSSARY.

Pneumatic Trough—A vessel in which chemists experiment upon aeriform bodies. It consists of a small tub, having a shelf extending over half its area, pierced with a hole, under which is an inverted funnel. Water is poured in until it covers the shelf. A bottle filled with water, and placed over the funnel, may be filled with air by pressing it into the funnel: the water is thus displaced, and the air experimented upon may be transferred, by means of a stop-cock, to a bladder or to another bottle.

Analysis is a chemical operation consisting in a separation of compound substances into their component parts. This operation may be designed to show the nature of the matters making up a compound, and is then called *Qualitative Analysis;* or it may be intended to discover the exact amount of each separate constituent, when it is termed *Quantitative Analysis.*

Gas is synonymous with air.

Geognostical—Belonging to the general constitution of the earth.

Organic Substances—Matters formed in the bodies of animals or plants, but devoid of mechanical texture, such as sugar, gum, starch, &c.

Organized Bodies—Parts of plants and animals in which a texture is perceptible, such as cellular tissue, muscular fibre, &c.

Algæ—Sea-weeds.

Fungi—Plants of the mushroom kind.

Proto. Deuto, Per, &c. are prefixes, borrowed from the Greek, to express the degrees of oxidation which bodies undergo—first, second, third, &c.

Basic Salt—A salt in which the base predominates over the acid.

Albumen—An organic substance, found both in animals and vegetables. White of egg is a familiar example of the former.

Specific Gravity—The relative weights of equal volumes of different bodies. Water is taken as the standard for fluids and solids, and hydrogen gas for aeriform bodies.

Sulphuric Acid—Oil of vitriol.

Hydrochloric Acid—Muriatic acid. Spirits of salts.

THE Book which it has been determined to republish, and offer next to the patrons of the Farmers' Library, bears the following title:

THE

PRINCIPLES OF AGRICULTURE.

BY ALBERT D. THAËR.

Translated by WILLIAM SHAW, Esq. Member of the Council of the Royal Agricultural Society of England, and Hon. Mem. Cer. Agri. of France; and CUTHBERT W. JOHNSON, Esq. F. R. S.

The high character of the English Translators, and the intelligent community to whom they have ventured, in the present advanced state of Agricultural knowledge, to offer this as "THE GREAT AGRICULTURAL WORK OF M. VON THAËR," would warrant the strongest presumption of its excellence; and examination of its contents has but served to justify the inference. But this is no place for an introduction. If any further provocation to read and study the "PRINCIPLES OF AGRICULTURE" were needed, that provocation will be found in the perusal of the *Memoir* of the Author, prefixed to the work; for it may naturally be concluded that the production of a man so highly gifted, enjoying such opportunities to obtain practical knowledge—a man, in short, whose "friendship," as that memoir states, "was courted by the most celebrated Agriculturists of England, France, Denmark and Germany, and whose works were studied every where"—must be worthy all attention. Having advised the reader of what we have next in store for him, it must be left, for the rest, to his own judgment, allowing him that degree of discretion which even plants are said to possess—to select that which is available and nutritious; rejecting all that is otherwise, of which we can promise him the proportion will be very small.

J. S. S.

P. S.—This work was only very lately published in England, making two octavo volumes, and costing here about \$10. The patrons of the Farmers' Library will have it at a cost of certainly less than \$2.

New-York, August 1st, 1845.

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WILLIAM SHAW, ESQ.

MEMBER OF THE COUNCIL OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND,
AND HON. MEM. CER. AGRI. OF FRANCE.

AND

William

CUTHBERT W. JOHNSON, ESQ. F. R. S.

NEW-YORK:
GREELEY & McELRATH, TRIBUNE BUILDINGS.
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INTRODUCTION BY THE AMERICAN EDITOR.

As announced in the last number of the FARMERS' LIBRARY, we commence here the republication of the "great work" of a German author, on THE PRINCIPLES OF AGRICULTURE, translated lately in England by men with whose names all are familiar, who can claim much familiarity with Agricultural literature.

The perusal of these volumes brought to mind the answer of two distinguished American scholars, who, being asked—If required to renounce the use of all the foreign languages they had mastered except one, which one they would retain? both at once replied, "the *German!*" For although, said they, more of the diversion of light literature and the charms of fiction may be found in others—though in the departments of Historical knowledge, of Military narrative, and Nautical discovery—though in the annals of Biography or the regions of Poetry, other tongues might be more fruitful—yet, said they, for solid, scientific and useful information, the German is the key that unlocks the richest treasures.

Applying this remark, as we believe it may be applied, in reference to Agriculture, to the work in hand, it yet requires to be read with profound attention; and the more it is so read, the more treasure it will be found to contain. So studied, with discriminating allowance for obvious difference of circumstances, every page will be found to have its value, based, as is the whole work, on profound philosophical meditation and research, rectified and assured by practical experience.

We would not be afraid to stake our judgment on the affirmation that in the single chapter of AGRONOMY, for instance, (a somewhat high-sounding and ostentatious title,) the attentive reader will acknowledge ample recompense in the knowledge it will give him of the constituent parts and physical properties of the soil, and the best method of acquiring a knowledge of the different earths, and their value in particular crops—a knowledge as necessary to those who are about to embark their capital and time in Agriculture, as it is for the manufacturer to possess nice judgment in regard to the materials adapted to his fabrics, whatever they may be.

But why should we anticipate the contents of the work, or attempt to forestal the judgment of the reader? As in society men come together easiest through the kind offices of a mutual friend, so there seems to be a sort of conventional understanding that the Editor or Author shall introduce his book to the reader. This it would not be fair or honest for him to do, if he did not believe it to be worthy of his acquaintance; and if he does, it will not be taken amiss that he should endeavor by a kind word to smooth the way to familiar acquaintance. That done, in this case, we commit this portion of the Farmers' Library to the judgment of its patrons, only advising them, further, that the 1400 pages of the original will be given in this volume, with an Index and a Glossary, that will serve to make certain terms, as well as weights and measures, used in the work, better understood by the American reader.

The Agricultural habits and practices of the two countries, arising more from other causes than from any essential difference of climate, or staples, or animals, or implements, might at first sight appear to suggest an omission of much, if not a recasting of the whole work. But this would be impracticable, and, besides, is unnecessary; for that portion which does not apply to our country and circumstances, is proportionably so little, and so dovetailed with that which is well digested, profound and suitable, that it would be unwise to meddle with it. The small excrescences, at the worst but useless, could not be dissected without danger of injury to vital parts.

All that we regret is, that while we are satisfied and take much pleasure in the belief that this work on the Principles of Agriculture, will be read with hearty approbation and decided profit, it restrains us, for the time, from presenting so many other things on hand, which we are sure must tend to enrich the Farmers' Library, making it, as we have before said, what we so ardently desire to do—an amusing and useful companion and guide for the old and the young, the father and the son. If in this way we can lift the character of the American Farmer to higher intellectual distinction, and assist in causing the attainment of knowledge to be regarded as the surest path of honor, and the common goal of ambition, we shall prize it far above the highest official elevation in the power of any government or people to bestow.

Will those who would have the rising generation of Farmers thus instructed and thus inspired, assist in gaining an assured support for a work, of which that is, and ever will be, the principal aim?

J. S. S.

PREFACE TO THE LONDON EDITION.

IN offering to the notice of the Farmers of their country a translation of the great Agricultural work of M. Von Thaër, its Editors have only to request of those skillful cultivators an extension of the same kind feeling which they have on so many former occasions experienced from them. The appearance of the work has been delayed much longer than its Editors could have anticipated, by unavoidable causes in which the reader would take but little interest.

October 1, 1844.

[illegible] Daniel

MEMOIR OF THAËR.

Of an agriculturist so celebrated on the continent of Europe, and of an author so distinguished as the author of these volumes, the English farmers will be glad to receive some information. The editors, therefore, deem it unnecessary to apologize for the introduction of this sketch, the materials of which they have chiefly obtained from his Life, published in 1839, at Leipsic, in one volume, by his son-in-law, M. Keorte.

Albrecht Daniel Thaer was born in Oelle, a neat little town in Hanover, on the 14th of May, 1752. His father, Johann Friedrich Thaër, was physician to the Court, and born in Liebenwerda, in Saxony; his mother, Sophie Elisabeth, was the daughter of J. Saffe, receiver of rents and taxes of the district of Celle. Albert was the first-born, and had three sisters, Christine, Albertine, and Wilhelmine, of which the first died in infancy, the second was married to Captain Schweppe, and the youngest to the well-known privy counsellor, Doctor Jacobi.

Very little would have been known of his early years of boyhood, and his academic life, were it not for some manuscripts found amongst his papers after his death, and a letter addressed to his future consort, headed "*My Life and Confessions, for Philippine;*" in which he thus expressed himself:—

"My father was a cool-tempered and unaffected man. Every one who came in contact with him knew his straightforward way of acting, his scrupulous honesty; but few, very few, of his friends knew his noble and manly heart. Indifferent to praise and fame, as well as calumny, he was ever anxious to do good in silence; and it can be said of him, without fear of contradiction, that during his whole life he could never reproach himself with having been guilty of a bad or mean action.

"My mother, as much as I can remember from my early boyhood, and from what I heard of her after her death, was of a most lively temper, and possessed of a good and noble heart, but a little inclined to sensibility; her greatest pleasure was to see every one happy about her. She loved me dearly and spoilt me. I adored her. Alas! I lost her when only a little boy, and never shall I efface from my memory the day of her death and funeral. I was very sickly and weak during the first years of my infancy, and was, as much as I can remember of myself, a very whimsical boy. Sometimes I learned with enthusiasm, and often found myself in such a kind of ecstacy that I neither could see nor hear what passed around me. In these fits of thought I forgot playthings and playfellows; I was happy only in my own musings. I always preferred the company of little girls to boys. I was not ten years old when I presented them with some poetry and little verses, the effusions of my heated imagination; some of them fell into my hands in riper years, and, after reading them over, I left off poetry altogether. I loved my first private teacher very much; I even can remember him now. My second teacher was a simpleton; he could never understand me, nor enter into my feelings. My antipathy to this man grew daily greater; I could not learn of him, nor could he teach me anything. At last, when in my thirteenth year, I got rid of him, and he being encumbered with debts, I gave him my saving-box when he left.—Whether I did this for pity's sake, or joy to get rid of him, I did not know. My father sent me, the same year, to school, but here I was not in my sphere; I hated the low and vulgar conduct of my school-fellows as much as the vulgar mode of correction of the masters. However, I selected some boys a little better educated for my daily companions, especially one of the name of Strauss,

who unfortunately combined with his romantic ideas a great inclination to drink; we daily played truant, but nevertheless I applied myself in my private lessons with great eagerness and perseverance to the study of mathematics, history, &c. so that I contrived to ingratiate myself in the good opinion of my masters. who never missed me during the school hours, being always ready when called to my class. My best friend amongst the masters was a teacher of the French language, named Ferry, who professed secretly all the principles of freethinkers. He procured for me all the works of Voltaire, and other French freethinkers, and, some time after, when I understood English, all the works of freethinkers of that nation. This was a pretty preparation for my confirmation, which was now at hand. The religious instruction I received of the Lutheran pastor Bode, preparatory to my confirmation, produced no effect upon my mind in favor of the truth of our divine religion, having studied all the works written against it with so much energy. I often insinuated to pastor Bode my doubts on religious matters, but either he did not or would not understand me; I was wavering between deism and atheism—so much so, that had it not been for the love towards my revered father, and the persuasions of Ferry, I should have avoided being present at the imposing and sacred ceremony of confirmation, which produced such an effect upon my young mind, that I prayed sincerely to God to give me faith; and had I not continued to read with Ferry and one Belzing so many blasphemous works, I should have returned to my former religious principles much sooner, as I did at a later period of my life. I continued for some time longer to ramble with Strauss and other school-fellows, to visit coffee-houses and billiard-rooms, but had a great antipathy to other debaucheries. The company of comedians of Mr. Seiler came just now to Celle, performing comedies and tragedies. This was a new life for me; I became acquainted with each individual of this company; they all were fond of me; the beautiful Madame Koch gave me lessons in dancing, and I suddenly deserted all my former companions, neglecting them to such a degree that one Mackphail, considering my conduct as an insult to the whole school, sent me a challenge, which ended in my wounding him in the hand. My father loved me dearly, but did not much inquire into my conduct: he allowed me a great deal of money, but owing to my attachment to Ferry, whose salary was but small, I provided him with money, and having myself an extravagant taste for dress, I was often in great difficulties to pay my bills, of which my father was ignorant, till my creditors became troublesome, and my good father immediately discharged them, after giving me some kind admonition.

"I was now in my sixteenth year, and for the first time it occurred to me that, although conversant with the most of the modern languages, I did not understand a word of Latin, and thought the knowledge of this language indispensable to my future prospects in life. I spoke to Rector Steffens, and got permission of my father to leave school entirely, and devote my whole time to the study of Latin. In less than twelve months I was completely master of a language which is often the torment of boys from their sixth to their twentieth years, and still remain ignorant of it. Since then I have written several pamphlets in Latin, which were admired; and in Göttingen my Discourses were generally delivered in that language. Doctor Taube, physician to the king, gave me lessons in natural history, botany, and anatomy; I bade farewell to philosophy and *belles lettres*, and began in earnest, and with great perseverance, to study physic; but still I was in bad odor amongst many of the learned, and it was said, when they heard of my progress, that henceforth they should not despair of making something of the most stupid of pupils.

"In my eighteenth year, my father sent me to the University of Göttingen. The first winter I did not leave the Anatomical School, and although I gave myself up to the most intense study, I willingly entered into all the gaieties and amusements so much sought by German students, but avoided carefully debaucheries of any kind; they gave me the cognomen, *Half Renommist*, owing to my puerile look and feeble and weak voice. Unzer and Ebeling, two students in physic, took me under their powerful protection, and extricated me out of many scrapes.

"In the second year of my residence in Göttingen I entered my name for a course of lectures on practical physic, against the advice of all my friends, but I have never regretted so doing, as there never has been, and probably never will be, a greater man at the university than Doctor Schröeder, physician to the king, who gave, at that period, his celebrated lectures on practical physic. Schröeder himself was astonished at the step I had taken; but when he perceived that I fully understood him, I became one of his favorite pupils; nor had I the advantage alone of receiving private lessons *gratis*, but he took me with him in most of his professional visits, where I had all the advantages of his great practice. Thus I caught a putrid fever which was then very prevalent; Schröeder attended me day and night, and, giving up all hopes of my recovery, he observed to one of his friends, not thinking that I understood what he said, 'The expansion of the sinews increases.' 'Then,' answered I, in a quiet manner, 'I shall

die in four days, according to such and such a rule of Hippocrates: pray prepare my father to receive the news of my death.' However, immediately after, a sudden turn in the disorder taking place, I soon recovered; not so my memory, which I lost for a time, so that I had forgotten the names of my best friends; my nerves were so completely shaken, that I had no wish to recover. After my recovery, Professor Schröeder being himself attacked with the same fever, requested of his wife that no other physician than myself should attend him; but when he became light-headed, she called in all the physicians of Göttingen, and these gentlemen not agreeing in opinion respecting the treatment of the patient, this great and learned man fell a victim to ignorance and jealousy, April 21, 1772. I cannot think of this celebrated and good man without shedding tears of regret and gratitude.

"After his death I did not attend any more lectures, although I paid for them. Schröeder was succeeded by Ernst Gottfried Baldinger, born in Gross Vargula, near Erfurt, 1738; and descended in a direct line, on his mother's side, from Doctor Martin Luther. He established a dispensary for poor patients, and gave medicine *gratis*, on condition of his being attended by about thirty pupils. Here it was that I first began to display the knowledge I had gained from my friend, the late Doctor Schröeder; and Baldinger, not seeing me attend his lectures, naturally supposing I was lazy and dull of comprehension, exclaimed, with astonishment. "What will become of this boy?" Whereupon, considering myself insulted by the Doctor, I wished to retire; when he embraced me and said, good-humoredly, 'No, no! such a clever young fellow never came under my observation.' From this time I became his best friend and daily visitor; I passed whole days and weeks in his valuable and extensive library, and almost in the constant society of his amiable, highly gifted, and accomplished wife; his confidence was so great, that he left the entire direction of his dispensary to me, and even entrusted me with the care of his own family when unwell. Having given up all connexion with my former friends, the students, I selected one Leisewitz, the author of 'Julius de Tarent.' We sympathised in each other's feelings, and became inseparable. His amiable qualities and inoffensive wit drew around us the best society; but, to our great regret, many of them belonged to a new school of freethinkers, whose principles we endeavored, by the assistance of the pious Madame Baldinger, to eradicate from their minds; and thus it was that Providence brought me over again to the firm belief of the truth of our Divine religion.

"In the mean time I paid the strictest attention to my profession, and was so completely successful, that there was no patient of any consequence in Göttingen that I was not called in to; but as I was not allowed to make up prescriptions, not having taken my degree, and in order to avoid a heavy penalty, I was accompanied in my professional visits by Doctor Tolle, a man who knew the lectures of Schröeder by heart, but did not understand them. I dictated to him what to prescribe, he took the fee, and was content. I had nothing but the honor, and plenty of good dinners. At last I took my degree as Doctor of Medicine, and resigned my patients to the care of Dr. Strohmeyer, which was the means of introducing him into practice. I left Göttingen full of honor, with tears in my eyes, at leaving behind me so many dear friends. Puffed up with pride, I arrived in Celle, but was received with coldness and pity. This was too much for me; I could not brook the insult; but said to myself, 'How can I expect to be otherwise received, when I consider my former conduct, and look back on the heedless manner in which I passed my boyish years?' My consolation was, that 'I should be soon as happy here as I was in Göttingen' *in the choice of my friends*. The physicians in Celle were fifteen years behind in their practice; they had heard of a new style of practice, but regarded it as a mere chimera. When I ventured to say a word or two, they did not understand me: when I appealed to some great authority, they were ignorant of it: when I spoke from my own practical experience, they looked at me, from head to foot, and said sneeringly, 'Well, well: experience will come in time.' But when by chance I ventured to make some proposal, they turned round, and wondered where they should find room enough in the churchyards to bury my patients. The great applause with which my Dissertations had been received in all the learned journals, even in England as well as in France, gave me courage, hoping that this circumstance would make some impression on the mind of the public; but it was generally thought I had ill employed my time, and knew little or nothing. Being obliged to frequent society, I was so disgusted with the general tone and the topics of their conversation, that I was almost in despair; at last, some young ladies treated me with more attention. I began to reconcile myself to my forlorn condition, but still I was not what I wished to be: the worst of all was, I had no friend; not a human being that understood me. I wrote daily to my friend Leisewitz; he resided in Hanover, and was just as unhappy as myself, except that he had some friends, and plenty of money. In this respect I was differently

situated, and although in want of money to buy books, I was determined not to be any expense to my father. Some watches, snuff-boxes, and rings, presents I had received in Göttingen, soon found their way to the hands of Jews at half price. I was even, against my will, driven to the necessity of accepting small fees from mechanics and peasants. This cut me to the heart; but I could not help myself. The following circumstance, however, overcame me more than all: My father was a man of great knowledge and experience, but, like all old men, he remained faithful to the old method of practice. I visited many of his patients, and without telling me exactly what mode of treatment I was to pursue, he only observed, 'You will act so and so;' however, I saw the patients had confidence in my father only, and not in me; they wished me to be his tool, and I therefore followed his mode of practice, and thus lost several of his patients, who could have been saved had I followed my own method. Among others, Doctor Caritens died during a momentary absence of my father, who recommended while stepping into his traveling chariot, to bleed the Doctor a second time. I did as he bid me, although convinced that emetics and opening medicine would cure the patient without fail; the Doctor died, and you may easily imagine the state of my feelings. I had just begun to publish a work on practical physic, but had no heart to finish it after this sad catastrophe. I betook myself again to philosophy. I wished daily to return to Göttingen, if I could do so with honor. I passed three years under such painful circumstances, when my friend Leisewitz invited me to go with him to Berlin, for which purpose his brother-in-law in Brunswick would advance me money to defray my expenses. Without much consideration, I accepted the invitation, and my portmanteau was soon ready. Arriving in Berlin, I found myself in my element, and began to breathe freely. Jerusalem and Lessing had given us letters of introduction to the greatest men in Berlin; but they knew us already, Leisewitz as author of 'Julius Von Tarent,' and myself as the author of my Dissertation. We had daily the choice of the first society; covers were laid for us in the first families daily, for dinner as well as supper. Von Zetlitz sent a general invitation that covers were laid for us every day during our stay in Berlin. Most of the time we could spare was divided between physicians and philosophers, of which the latter had the greater share. Spalding, Mendelssohn, Eberhard, Engel, Nicolai, Reichard, and Mdme. Bamberger, daughter of Doct. Sack, Bishop of Berlin, honored us with their most sincere friendship. The latter, a highly gifted and accomplished lady, possessed the rare art of spreading over the most abstract hypothesis and theorem the brightest and most charming light; Jerusalem, the father of the ill-fated Werther (see the 'Sorrows of Werther,' by Göethe), used to send her his works to correct, and she alone alone was able to console and comfort him, when he was informed of the death of his beloved son. This amiable lady assumes in common life the character of a plain woman, and when at court, as friend of the Queen and the Princess Amalie, she won all hearts by her truly noble manners and unconstrained courtesy; at court beloved, she was admired, nay, adored in the philosophical clubs. But do not think that here alone we spent all our time; Madame Bamberger knew how to blend study with amusement; she issued frequently cards of invitation to select parties, for suppers and balls, and her house was the point of union of all that was learned, beautiful, and amiable. Thus Berlin became my Paradise. I had the most tempting offers from the Minister of State to stay here; but the illness of my father obliged me, after a stay of three months, to return home. I visited Lessing on my journey back; stayed two days, which were the most interesting of all days I ever remember. It was now, I thought, high time to think earnestly of getting into good practice as a physician. I followed, in order to effect this, my own method; I cared not for criticism; good luck attended me; I was successful in many cases given up by others as hopeless. My father watched me now closely, but let me have free sway; he felt great pleasure at my success and would now and then say, 'Well done, my boy;' but nevertheless entreated of me not to offend a certain great personage; which, however, I frankly confessed I had already done, not caring much about it, as it was my intention not to stay in Celle. I wanted a greater sphere of action. My father's weakness and infirmity increased daily, which prevented him from visiting his patients, and determined him to give up altogether his practice, and to retire from a profession in which, during many years, he had so nobly done his duty; he informed his patients of it, telling them that they were perfectly free and at liberty to take the advice of his son, or any other physician, thereby insinuating, that in their choice they must not suffer themselves to be influenced by their feelings of friendship and regard towards him. Almost all his patients honored me with their confidence. Now, my dear Philippine, a few words more. I am not rich; but my affairs are not in a deranged or desperate state, and were I to die to day, and my property sold, it would fetch 5,000 dollars at least, so that I possess 2,000 dollars more than my father gave me. I have but 400 dollars salary; my practice is good, and becomes daily more lucrative; the income I derive from it now is more than sufficient to keep a

good and respectable house; my prospects are flattering; but I can and must not name them at present; I will not bring them into account."

Here ends the letter addressed to his future consort; he calls it his confession, and surely the writer proves throughout that he was guided by a most sincere and open heart. He was now physician to the parish and the House of Correction, and shortly afterwards, (1780,) without soliciting for, or even expecting it, he was appointed physician to the Court of Hanover.

Thaër, being now at the summit of his profession, he was called in to all consultations, far and near; his opinion always had weight. His noble demeanor, the great kindness and affability with which he treated every one, rich or poor, won all hearts. His talents were held in the highest estimation; in short, he was looked up to by all. However, Thaër, (although the learned Himly called him the most talented and most successful man he ever knew in his profession,) notwithstanding his great and lucrative practice, got nevertheless daily more and more tired of it. This must be attributed to the sympathy for his patients, and a kind of sensibility which he never could conquer, and which induced him, several years afterwards, to relinquish a profession of which he had been the ornament, and still, at this period, continued to be, to the greatest joy of his friends and admirers. Thaër now thought seriously of his marriage; he had opened his heart to Philippine—he loved her dearly, and was loved in return. Her parents, however, and herself, being very religious and devout, could not forget his younger years; a pamphlet on religious matters, written with great freedom and wit, made a great noise amongst the orthodox clergy and laity; it was published by Lessing, under the title of "Fragments of the Unknown of Wolfenbuttel," but presumed to be written by Thaër. This circumstance was for a time a great obstacle to his happiness; but, at last, his great fame, and the general esteem he enjoyed, brought on the happy day of his union with the object of his affection. He was married on the 19th of April, 1786. His lady was the daughter of a nobleman, and President of the High Court of Appeal in Celle. His name was George William Von Willich.

Thaër, immediately after his marriage, moved from Celle to a little garden beautifully situated on the river Aller, near the town. After having bought this piece of ground, he built a small cottage upon it, furnished it handsomely, and spent there the honeymoon. He was now happy; but became daily more averse to his profession. In his hours of relaxation, he amused himself by cultivating flowers, and thus became a florist. The garden became now too small for him; he enlarged it considerably, making a purchase of sixteen acres of ground, and enclosing the whole.

Thaër's garden soon became the admiration of the inhabitants of Celle; and when he began to lay out plantations and orchards, to cultivate herbage and vegetables, the whole country were astonished at his science in the art of cultivation. But Thaër was not the man to stop here; he now seriously contemplated the improvement of Agriculture, and, in order to carry out his plans, he purchased a considerable tract of land. He followed his agricultural pursuits with heart and soul, at the same time not neglecting his patients. He was daily seen, when coming home from his visits, running to the plow, or occupying himself in his fields, orchard, or garden. Just about this time, (1796,) when he seriously contemplated the relinquishing his profession, could he do so with honor, he received from London his patent as physician to his Majesty George the Third. This honor was unexpected, not having been solicited; he could not well, under these circumstances, withdraw himself at once from his profession, but began by degrees to resign his practice, and recommend those professional men he thought most clever. Thaër, having now more time on hand to pursue his favorite occupation of the improvement of Agriculture, kept principally in view the establishing an experimental husbandry, and the improvement of bad and ungrateful soils to such a degree as to yield a good, or, at least, a proportionate return for the money laid out. He likewise studied the best works on Agriculture: Bergen's work, published 1781, on Improvement of Breeding Cattle and Stall-feeding, was very useful to him, of which work a new edition was published in Berlin, 1800, by Thaër himself, who enriched the same with his own remarks and experimental observations. He took, likewise, the advice of his friend, Schubard von Kleefeld, so celebrated as an enthusiastic freemason, introducing the system of strict observance, or reëstablishing the system of Templars. Thaër gave Schubard the name of "The ardent apostle of the culture of clover and stall-feeding;" he little thought then that he himself would soon excel him. He combined with the culture of herbage fodder, the growth of carrots, cabbages and potatoes—which latter root he most vehemently defended against its numerous adversaries and assailants. His agricultural implements were of the most ingenious kind, and mostly made in England. His work on English Husbandry was so well received in England, that the Board of Agriculture sent him unanimously their thanks. The letter was dated Whitehall, June 6th, 1797:

"*Resolved*, That the thanks of this Board be given to Dr. Thaër, D. M., of Celle, in Germany, and physician to his Britannic Majesty, Elector of Brunswick Lunebourg, for his late valuable communication, as well as for the intended treatise he promises to send to the Board, as soon as printed, comprehending a comparative view of the British and German Husbandry.

[L. S.] (Signed) "JOHN SINCLAIR, President."

Thaër's fame was now known from one end of Europe to the other. The most celebrated agriculturists of England, France, Denmark, Germany, &c. courted his friendship; his works were studied everywhere, when, curious to relate, the farmers in his immediate neighborhood called him the English farmer, and called his farm a toy to play with. Thaër now set out on a tour through Denmark and Germany, visiting all the great landed proprietors; he made a long stay at Essenrode, with his most intimate friend, Director Von Bulow. "To him," he says in a letter to a friend, "I owe my success in agricultural pursuits;" and when, in 1802, he was informed of his death, he wrote again, "In Bulow I have lost my best friend, my teacher and benefactor. I shall ever remember this truly noble man, and shall ever be grateful to him."

Thaër received a great many visitors of distinction, anxious to see his establishment and visit his school for the study of Agriculture, which he had lately formed. Amongst the first was Baron Von Hardenburg, afterwards so well known as first Minister and great Chancellor of the King of Russia, with the title of Prince Hardenburg; he was accompanied by the talented Benjamin Constant, who had married the Countess Hardenburg. These frequent visits, and the immense number of letters he received from all parts of Europe, and many of which he was obliged to answer, took up much of his time; so that he was, although reluctantly, obliged to request his numerous correspondents, through most of the continental newspapers, to spare him as much as possible, and not to write him on trivial matters. The year 1803 was fatal to him—the French occupied Hanover; he immediately sent his wife and two children to Prussia, where they were most heartily received by the Countess Von Hzenplitz in the Mark, and stayed there till the French army evacuated Hanover. The French Generals Mortier, and afterwards Bernadotte, treated Thaër with great kindness and respect. His property was protected; he continued his pursuits quite unmolested, as well in his school as in the field: but his heart ached; he saw his country wasted; he feared the French would keep possession of Hanover for a length of time; or, should they be obliged to evacuate it, a war, in which Prussia and Russia would take part, must ensue, and the whole country would be ruined. He had received several letters from Hardenburg, inviting him to settle in Prussia, and although the offers were tempting, he declined accepting them; till at last he received a pressing letter from the King himself, inviting him to come and reside in Prussia.—The following advantages were granted:

1. Thaër's nomination as member of the Academy of Sciences.
2. A grant of 400 acres of land in the district of Wollup; but,
3. Should this land not suit for agricultural experiments, or the situation of Wollup not be eligible for the establishment of an Agricultural Academy, Thaër was at liberty to sell the land and buy a freehold, granting him all the privileges attached to a landed estate belonging to a nobleman.
4. Protection granted to his academy, and such privileges as are requisite for obtaining the object for which it is established.
5. Entire liberty of the press in regard to the Agricultural Journal, of which Thaër was the editor.
6. Permission to practice his profession as physician.
7. His nomination as privy counsellor.

Thaër set out for Berlin in June, 1804, accepting the offers of the King; took possession of the 400 acres of land, sold it immediately, and bought a landed estate called Möglin, with all the privileges of a nobleman attached to it, and added to it a large farm called Königshof, not far off.—This property is situated in the Mittel Mark, about five German miles distant from Berlin. He took possession of Möglin on the 30th of June, 1804, and returned once more to his native town in order to arrange his affairs and take leave of his numerous friends. He did not lose time, but immediately sold by public auction all his property; even his valuable library and medical apparatus were assigned to the hammer. He closed his school at Michaelmas, took an affectionate leave of his pupils and friends, and left Celle on the first of October, accompanied by his family, his friend Einhoff, and his gardener and family—in all, twenty-three persons. On his arrival in Prussia, Thaër was not idle; he immediately took such measures as would best ensure the object of his undertaking. In the purchase of Möglin, he had not consulted his own interest, the soil being rather poor; but his establishment being experimental, his sole aim was to improve the soil.

and to bring it to such a state of cultivation as to ensure a commensurate return in proportion to the capital and labor. The first years of his residence in Möglin proved unfortunate to him; the rot destroyed most of his flock of sheep; then came the preparation for the war of 1806, so unfortunate for Prussia; the occupation of the whole kingdom by the French for some years; the great want of money, and impoverishment of the middle and laboring classes, and the devastation of the greatest part of the country. Thaër could not foresee the great calamities which assailed him almost on his entrance in Prussia; but notwithstanding all those untoward circumstances, he stood firm, devoting most of his time to study, hoping that soon he might be enabled to establish his academy. He considered it as his duty towards the King and the whole country, to keep his promise as soon as circumstances of a more favorable nature would enable him so to do. The building was, indeed, finished by June, 1806, and the opening of the academy was fixed to take place on the 16th of October; but then came the battle of Jena and its consequences. Thaër still despaired not, and to his great joy he received twenty pupils during the following year; this number increased yearly, and at length he had the great satisfaction and unspeakable pleasure of seeing his great work finished. It is needless to say that after the peace of Tilsit, when Prussia recovered from the deep wounds that the war had inflicted, Thaër was not idle in the cultivation of his estate, which he brought at last to the highest state of perfection; but, above all, he distinguished himself more than any one before by improving the quality of sheep's wool. He stood now on the pinnacle of his glory; almost all the sovereigns of Europe complimented him on his great success. Those of Prussia, Russia, Saxony, Hanover, Bavaria, and Wirtemberg, sent him their orders of knighthood; noblemen from all parts of the world came to visit him, especially from England. They always met with a truly cordial and hospitable reception; he made no distinction between high or low, rich or poor, provided they conversed with him on Agriculture or breeding of cattle, and had some knowledge of it. Thaër enjoyed good health till 1824, when he suffered much from rheumatism and a troublesome cough. He visited, during the summer, the watering-place, Obersalzbrunn; but deriving little benefit from drinking the waters, and not being accustomed to an idle life, he soon returned home; the chief reason, however, was, that the etiquette of the place would not allow him the smoking his pipe, of which he was very fond.—He made a last purchase of the united freeholds of Ludersdorf and Biesdorf, which he destined for his younger son, Albrecht, who was entirely devoted to agricultural pursuits. His strength now began to fail daily, and he kept his bed during the winters of 1826 and 1827, and had his pupils called in for instruction. However, as the disease under which he labored increased, no hope for his recovery could be any longer entertained. His mental faculties remained in full force, but his eye-sight failed entirely, and one of his children was always with him and reading to him. His sufferings were great, but he bore them with great fortitude and resignation. The most celebrated medical men in the kingdom visited him, and paid the greatest attention to his complaint. Doctor Dieffenbach was in constant attendance; but he sunk gradually, till at last, on the 26th October, 1828, death put an end to his sufferings, deeply lamented by his family. He left a wife and six children, and a circle of numerous friends. He was, according to his desire, buried in his garden, close to the church, without any display. No monument marks the spot where the ashes of this great man lie; and if you pass by and inquire after the grave of Thaër, you are shown a little hillock covered with flowers.

Thaër was the author of a great many useful works. It is to be regretted that most of his manuscripts and journals were lost on his moving from Celle to Möglin; they were packed in two boxes and sent up the Elbe; the winter setting in very early, and being very severe, the ship was frozen in, and on arriving at the place of destination in the following spring, these two boxes could never be found, although Thaër, assisted by the Government, did all he could to recover them.

CHRONOLOGICAL LIST

OF

THAËR'S AGRICULTURAL WRITINGS.

1798. An Introduction to a Knowledge of English Agriculture; containing the latest Practical and Theoretical Intelligence, with a view to the improvement of German Agriculture; 3 vols., published in parts, between 1798 and 1804; third edition, 1806.
1799. Annals of Lower Saxon Agriculture, 1799 to 1804; four parts to each year, (whether published quarterly not stated;) idea taken from Young's work; substance republished under the following title: "Miscellaneous Writings on Agriculture;" 3 parts: Hanover, 1805–6.
1800. Bergen's Introduction to Breeding of Cattle, or rather to *Fodder Culture*, with remarks, corrections, and additions, by A. T. Thaër: Berlin, 1800.
1803. A Description of the most useful Agricultural Implements, with drawings to scale; 3 parts: Hanover, by Hahn, 1803, 4to.
    [Publication interrupted by the war.]
1804. Benjamin Bell's Agricultural Essays; translated, with Explanatory Notes, by A. T. Thaër, 1 part: Berlin, 1804; together with Rhapsodical Observations on the above Essays, 1804.
    [Publication interrupted by the war.]
1805. Annals of Agriculture, (6 years, 1805 to 1810;) in 12 vols.
1807–8. Thaër edited a work by Meyer on Irrigation, and Einhof's Chemistry of Agriculture.
1810. Principles of Rational Agriculture; 1st vol. in 4to., and 3 more vols. between 1810 and 1812.
    [The first three volumes have the signature of Thaër on the title-page, as a security against pirated editions. But, before the second part appeared, the first was already issued by some German pirates.]
1811. Annals of the Theoretical and Practical Progress of Agriculture, 1811 and 1812; 4 vols. 8vo., contained under the title of "Möglinischen's Annals of Agriculture," from 1817 to 1823, when the editorship, on account of the weakness of Thaër's sight, was transferred to Professor Körte, his son-in-law.
1811. Text-Book for the Breeding of Fine-Wooled Sheep. Published by desire of the Minister of the Interior: Berlin, 1811. (Superseded by another work in 1825; see that year.)
1812. Essay on Large and Small Farms, and Valuation of the Land: Berlin.
1813. An Attempt to Ascertain the Net Produce of Farms.
1815. Introduction to a General System of Agricultural Knowledge: Berlin, 1815.
    [This work is said to have been that on which Thaër most prided himself. He often called it "the quintessence of the first two parts of the 'Rational Agriculture.'"]
1815. History of My Farming: Berlin. This book contains an account of Thaër's experiments at the model-farm at Möglin.
1815. Sketch of a Circular to obtain more Correct Information as to the Net Produce, to serve as a basis for correct Taxation of the Land.
1825. On Wool and Sheep-Breeding; by Pérault de Jotemps, Fabry, and Girod. Translated from the French, and rendered conformable to the Present State of Knowledge of the Subject in Germany:—Berlin, 1825.

THE

PRINCIPLES OF AGRICULTURE.

SECTION I.

THE FUNDAMENTAL PRINCIPLES.

A SKETCH OF SYSTEMATIC AGRICULTURE.*

AGRICULTURE is the art of deriving from the earth the most valuable organic productions. He who exercises this art seeks to obtain profit by causing to grow, and by using, its animal and vegetable productions. The more considerable the gain derived, therefore, the better is the object accomplished. The most perfect Agriculture is, evidently, that which produces, by the application of labor, the largest and the most permanent profit in comparison with the means employed. Systematic Agriculture ought, then, to teach us all the circumstances by means of which we may derive the most considerable profit by the practice of the art. Now, there are three methods of teaching or of learning the practice of Agriculture.

1. As an occupation, by the manual exercise of it. 2. As an art. 3. As a science.

The skillful practice of Agriculture, as an occupation, is limited to the imitation of certain operations, and the observation of events and circumstances. It is nothing more, when thus pursued, than a simple mechanical art: for the practical farmer can only imitate and repeat the ordinary operations of Agriculture, occasionally modified by times and circumstances; and often, perhaps, without considering or even knowing the motives by which he is governed.

The art of Agriculture is the realization of some ideal object. He who practices it has received from others, without considering the reasons on which it is founded, the idea or rule by which he proceeds. The skillful practice of an art consists, therefore, in the adoption of new ideas, in the study of new rules, and in judging the fitness of their being carried into practice.

The science of Agriculture does not lay down any positive rules, but it develops the motives by which the best possible method of proceeding may be discovered and successfully pursued. In fact, the art executes some law given and received, but it is from science that law emanates.

Science alone can be of universal utility, embrace the whole extent of a subject, and enable us to devise the best execution of it under every possible circumstance. Every positive direction is applicable only to some determinate case, and each case requires a special rule which science alone can supply. That system of Agriculture can only be called the most perfect which is the most reasonable—for these are synonymous terms.

* In the translation of this admirable work of M. Von Thaër, the editors have adhered as closely to the text of the lamented author as possible—they have only omitted those portions which seemed but little interesting to the English farmer.

The manual exercise and study of the art can never be useless to the agriculturist who wishes to elevate it to the rank of a science, and to the mental consideration of which it is deserving. It will be advantageous to him to have experienced the labor and the energy which are necessary, in order that he may judge of the mechanical execution of the various portions of it.

A purely practical agriculturist is compelled to follow the rule which has been laid down for him, although it may not be wholly applicable to the peculiar case which presents itself. He cannot depart from it without adopting some other rule, which may, perhaps, deviate entirely from the first.

This is the reason that so many agriculturists, who have practiced with success in other countries, and under other circumstances, on being removed elsewhere, have committed very deplorable blunders.

Thus, the man who has not studied the science of Agriculture can make little use of books, or even the best of them. He knows not how to arrange the new ideas which they unfold, and he cannot follow them in their fullest extent. All that he dares do is to read those books which have the closest relation with the circumstances in which he is placed.

THE BASES OF THE SCIENCE OF AGRICULTURE.

The science of Agriculture rests on experience; and nothing else should be required or expected from it but that which appertains to a practical science.—The first principles arise from the perceptions of the senses; but if experience wholly and entirely flowed from these perceptions, the development would not be less the offspring of science and the work of the understanding.

From the frequent union and the succession of objects, we conclude that a certain fact is the consequence or result of another; and it is the source of a vast number of errors that we are so much disposed to regard the occurrences which take place as the effects of those by which they were preceded. Unfortunately we have not, as yet, any positive or general indications which will enable us to distinguish between that which is simply the effect of a mere succession of time and that which is produced by another motive power.

A frequent and repeated union alone can authorize us to presume on the connection of two objects, as cause and effect. The oftener this union is repeated, the greater is the probability of this relation being founded on fact. This probability may, at length, become a moral certainty; but this certainty ceases entirely if one of these objects ever appear without the other, for then we should more or less presume that the one is not the only cause of that which is regarded as the effect.

The greater number of facts, however, when we view them in their whole extent, will be found to be the result, not of one sole cause, but of the union of several. If we have nine of these present and the tenth is wanting, the effect will not be produced, and even the contrary often takes place—for instance:

In order to produce a perfect ear of wheat, we require:

1. A sound grain of wheat, with the germ entire.
2. Some soil, carefully plowed and prepared.
3. A proper degree of moisture, neither too much nor too little.
4. A proper degree of heat.

All this is generally known, but it is also known that we require,

5. Atmospheric air; for no germ will vegetate in a vacuum.
6. A proper proportion of oxygen; for in air which contains no oxygen the germ will never grow.
7. Carbon; for without it a plant will only flower, and cannot produce any grain.
8. Light; without which the plant exhausts itself, is always weak, and perishes before it arrives at maturity.

All these different substances or agents, and perhaps many others, must be united in order to produce this effect—this ear of corn; and must all unite in their just proportions in order to bring it to perfection. Should the effect not be produced, it arises from some defect in one or other of these causes.

We can experiment either by means of simple *observation*—by examining the subjects and agents placed in relation with each other, and by considering their reciprocal action and observing its results; or by means of *trials*, or experiments

—by placing some well-known plant in certain situations determined with precision, observing their reciprocal action, and preventing, as much as we possibly can, any foreign or unknown body from influencing the results of our experiment.

A trial is a question addressed to nature: when such a question is properly put, Nature will necessarily reply either yes or no.

It is only within the last century that the art of making experiments has been clearly apprehended. It is on this art that the principal power of man over the material world is founded; and that power will become more extended in proportion as he brings this art nearer to perfection and carries it into full practice.

It is not often that, in an isolated situation, under the very hand of the naturalist, or in the laboratory of the chemist, any complete and satisfactory experiments can take place. They are beyond the active sphere of the agriculturist, properly so called. Nevertheless, the manner of recognising them, of investigating them, and disposing of them, is, as we shall see, of the greatest importance in the science of Agriculture.

There is a particular kind of agricultural experiments which have arrived almost at perfection, and which can be regulated with a degree of precision equal to that which is attained in the other practical sciences: these are comparative trials in the open air.

It is true that experiments of this kind are not easily made; but, nevertheless, they are in the power of every reflecting agriculturist. Whoever has accomplished one experiment, whatever may be the peculiarity of the circumstances under which it was made, and has given a faithful account of it, has well contributed to the advancement of science, and consequently to useful practice, and has entitled himself to the gratitude of his contemporaries and of posterity. It would surpass the power of any single individual to accomplish any considerable number of these experiments, and could not be expected from him. It is the duty of the Government to place some well-educated men in a position to employ their time and talents in investigating the secrets of nature for the advancement of Agriculture and the general good.

Agricultural societies, which are instituted for the advancement of science, should especially engage in the preparation of such experiments, and divide the execution of them among the several members.*

The number of these special experiments being as yet far too small, we are compelled to draw on the large collection of individual observations, imperfect as they are, to adopt them as the principles of our science.

Science would have made much greater progress if the false shame with which agriculturists conceal every unsuccessful experiment, and the exaggerated manner in which they often relate all those in which they have succeeded, had not retarded its progress.†

Natural history, which of late years has been brought to such perfection, renders very valuable assistance in laying the fundamental principles of our science; it affords a clue by which we may extricate ourselves from a labyrinth of imperfect experiments, and serves as a touchstone by which to judge of their truth and their value. Nature acts everywhere on uniform and eternal rules; and the agriculturist can only employ those means which she places at his disposal. It is this disposition which, with reference to Agriculture, enables us to derive a physical and chemical knowledge of the precise rules by which it is governed, or at least to obtain indications of the course which we must pursue in all our researches. If natural history only taught us to understand the nature of the soil, the varieties of its composition, and of what substances it is composed, that alone would have been sufficient to throw some valuable light on the numerous differences which are observed in the results of certain operations. These sciences have long exercised an influence on Agriculture. Latterly, chemistry in particular has been employed to enrich the science of Agriculture; and very great benefit has been derived from this union. We are now enabled to discard several extensively received prejudices, through our more extended observations on the surface of the country, and in rural economy, and to establish the truth of

* This plan is adopted by the Royal Agricultural Society of England.

† The author very justly animadverts on the "exaggerated manner" in which practical men have published the results of their experience, which have never been realized in continued practice even by the publishers themselves, and have not failed to throw doubts on all similar propositions. Moderation and caution cannot be too much recommended in such cases.

several facts which heretofore were merely probable. It is on this account that scientific instruction in Agriculture should always be based on sound notions of physics and chemistry, and that we should endeavor, by means of these sciences, to penetrate as far as possible into the principles and foundation of things; for, the want of success in our researches, and the reason that we do not arrive at more numerous and more sound conclusions, is to be attributed to our imperfect knowledge of the phenomena of nature.

The agriculturist is principally employed in the reproduction, the vegetation, and in maturing and perfecting the growth of plants. A knowledge of the organization and nature of vegetables, called *physiology*, is indispensable to the study of Agriculture; and also a knowledge of their distinctive characteristics, their natural and scientific classification and their nomenclature, or, in other words, *botany*.

And as it is a part of the business of the agriculturist to multiply animals and animal substances, some knowledge of the animal economy, and of the diseases to which it is subject, would be greatly conducive to his success.

No science can be said to be complete without the aid of mathematics, properly so called. But Agriculture requires the application of several branches of the mathematics; it demands a knowledge of arithmetic in its most extensive meaning; a calculation for the detailed accounts, and book-keeping.

It is, then, evident that Agriculture ought to borrow from every science the principles which she employs as the foundation of her own; and although the sciences do not form an indispensable part of the farmer's education, he ought, nevertheless, to have a general knowledge of them.

THE BASES OF ENTERPRISE.

An agricultural enterprise requires; 1st, a suitable person; 2d, capital; 3d, an estate.

Every person who seeks to practice Agriculture with the full success which it admits—and that is the natural aim of every one who engages in it—must possess energy, activity, reflection, perseverance, and a knowledge of all the kindred and accessory sciences.

It is true that it was once considered that the inaptitude which many young men evince for all other undertakings, is a kind of pledge that their proper vocation is Agriculture; and we have seen such persons, although continuing in a state of mediocrity, yet deriving much happiness from rural life. But this requires a concurrence of fortunate events that formerly might frequently occur, but which at the present day can rarely take place.

The practice of Agriculture is composed of an infinite number of different operations, each of which appears easy in itself, but is the more difficult to execute, inasmuch as they frequently seem to interfere with, and run counter to one another. In order to regulate them according to the circumstances and powers that are at our disposal, so that no single one shall be neglected, but each performed properly and in its due order, there is required the greatest attention; activity without anxiety; promptitude without precipitation; a care of the whole, united with the strictest attention to the most minute details; a judicious appreciation of all that is more or less necessary, and of that which belongs to different periods of time; an unremitting perseverance in whatever is undertaken, but which, however, does not lead to the neglect of more pressing duties; a prudent estimate of the value of labor and of time, so as to employ them to the best advantage.

As it is impossible that an enterprise like that of Agriculture can be exempt from casualties and accidents, a certain tranquillity of mind must be united with the necessary activity in order to secure a happy life. Whether this be attained by the consolations of philosophy or religion, the agriculturist must learn to support misfortune with resignation; he must forget all the evils which it was impossible for him to foresee, all those hopes which have ended in disappointment, so soon as he has, by the adoption of prudent regulations, diminished as much as possible their annoying consequences.

Rural life, in despite of the pleasures that attend it, has so much uniformity about it, and, with all its occupations, has so many hours of idleness, that it scarcely satisfies an active mind, that possesses no other object of employment.

In choosing an accessory study, the accomplished agriculturist will not find any one that will be more consonant with his feelings than natural history. He, better than any other person, can abandon himself to the consciousness of living in the bosom of Nature, and investigating her sublime laws; and so far from interrupting his usual occupations by this pursuit, he will almost always be able pleasingly and usefully to unite them.

If the moral world and the relations of society too often present us only with the painful spectacle of a resistance to the laws of reason which spreads grief and misery over the earth, Nature, on the contrary, unfolds to us more striking proofs of order and unity in proportion as we penetrate into her mysteries. The beauties which we discover not only gratify our taste, but they also afford us a demonstration that the Eternal Wisdom who unfolds to our view His operations in the material world—who is ever reproducing matter under new and admirable forms—will also in the moral world pursue an equally harmonious plan, the full completion of which is reserved for the ages of eternity. This feeling, although vague, is far more vivid in the inhabitant of the country than in the person who passes his time in populous towns. It is on this account that more true religion is generally found among agricultural people, than among those devoted to war or to commerce.

The man who feels within himself sufficient talent united with such inclination and taste, or who has manifested such a disposition from his youth, may devote himself to the pursuit of Agriculture with a good prospect of success; and, if he acquires a complete knowledge of it may attain the summit of his ambition. Let us now see how this knowledge is to be acquired.

It is, doubtless, most easily and most naturally acquired when the scientific instruction has been preceded by that which is derived from actual observation, from mechanical and practical instruction, or from an agricultural education, properly so called. Nevertheless, we have many examples of men who united inclination with distinguished talents, who, having received a good education, and having previously pursued occupations diametrically opposed to Agriculture, have become distinguished agriculturists by means of scientific instruction alone, and have, in a very short time, acquired a superiority over persons who had practised the art for many years and with great success.* Science had opened to them many ways which had been overlooked by those who had pursued the old routine, and had revealed to them with clearness and precision what years of practice had merely shown to others in a vague and obscure manner.

It is true that by far the greater number have, in the beginning, committed some errors in particular cases; they have to pay for their experience; but these errors are attributable to the hitherto defective system of scientific instruction.

With equal instruction and equal talent, that person will always have the superiority, whose education, good in other respects, has been directed towards Agriculture from his early youth.

A young man, fifteen years of age, will obtain the requisite education in an establishment which unites considerable activity in the different branches with the employment of the various means of obtaining the produce of the earth, although this establishment may not have attained the perfection of which it is susceptible. There the pupil will have all the objects and operations of Agriculture brought under the cognizance of his senses; he will acquire a practical knowledge of all the details; he will learn to select the proper season for each operation; he will form in his own mind a kind of intellectual admeasurement of the nature and value of soils, the seasons, and of the requisite labor. He will also there be taught all that has relation to the general management and direction of business, and he will carefully observe the manner in which it is conducted as often as opportunity permits. Lastly, he will not fail to acquire, as much as possible, a certain tact in buying and selling.

During more than a century the possibility and advantage of a scientific education for the practice of Agriculture has been maintained, and an agricultural

* The author alludes to persons who have not been bred to the art of Agriculture, and having adopted that profession, have much excelled the old practitioners, who follow the old routine. Many such instances occur, not only in Agriculture, but in many other professions. The mind is free from the bias of early prejudices; exertion is necessary; and when a man is determined to teach himself, it is surprising what the human mind can accomplish. The first step is a conviction that he is in want of learning; the rest will soon follow.

chair has been established in almost every university. In so far as it is the duty of these institutions to afford the public functionary, the lawyer, and even the theologian and the medical man, a clear idea of agricultural practice and its importance, I admit the utility of these appointments, and only desire that the instruction shall be directed to the sole end which it can possibly attain. *

These professorships, however, do not appear to me necessary or even useful to the agriculturist who seeks instruction there, because the nature of the life which is led there, and the usages of the university, and the general tendency of affairs in such places, seem to possess something altogether foreign to his habits and pursuits, and are calculated to unfit him for the peculiar species of activity and the peculiar kind of life to which he is destined. Besides, it is scarcely to be expected that an agriculturist, who unites practice with science, will accept a professorship of this kind at a university; and he who does not possess both these requisites is by no means fitted for such a situation.

Nothing can contribute more to the acquisition of an enlightened knowledge of Agriculture than traveling in those countries which are distinguished for the perfection of their Agriculture. The contemplation of practices and institutions so various among different people destroys that prejudice encouraged from our childhood, which leads us to believe that nothing can be done in a better or in a different manner from our own mode of performance. The customs of different provinces and of entire nations, as well in the general proceedings of Agriculture as in the performance of individual operations, are, with every thinking man, so many experiments on a grand scale, if he knows how to place them on a level with each other, and to compare their results. But it requires a great deal of perseverance, and the surmounting of many difficulties, to derive real advantage from such travels, and to extend the observation to the actual and true principles of things. They who have only run through a country as it were by post, and who stop only at the inns, will report very little that can be in any way useful. Besides, there would be required a correct judgment, and penetration founded on preliminary and long-continued study, and an impartiality altogether free from prejudice, in order to derive true and positive results from the observations which are made. Without such acquirements, so far from being divested of our preconceived notions, we shall only bring back others still less suited to our climate, and the circumstances in which we are placed.

We shall presently have occasion to add something on the direction of agricultural travels, the best route to be pursued, and, in fact, on the geography of Agriculture.

The cultivation of the land attached to a model farm, or other institution for teaching practical Agriculture, ought to be a pattern for agricultural practice, but it is by no means necessary that it should be perfect. It is far better that this model should be advancing towards perfection, without having yet attained it, in order the better to show the difficulties by which it is surrounded. It is also necessary that this cultivation should be carried on in the usual manner, and that it should not possess or employ any extraordinary resources which might cause it to advance more rapidly than would otherwise be possible. It ought not to employ in the attempts of improvement any disproportionate or an unusually large capital, nor any resources which would not be generally available.

It ought neither to purchase manure from towns in the neighborhood, nor to make use of too expensive means of improving the soil, such as an extensive use of the spade, the destruction of perennial crops, or anything of that kind; but the proceedings should be regulated by the strictest economy.

A very limited space of ground would be sufficient to demonstrate what can be effected by the above-mentioned operations.

Such an establishment ought to possess a complete collection of implements and machinery, and every arrangement necessary for the demonstration of the accessory sciences which would be taught there.

The conduct of the pupils, their intercourse with each other, and their proceedings in every respect, should be directed to the great end of the objects of the establishment; not by means of coercion, or by special rules, but by that interest and charm which the subject itself necessarily inspires.

It is in free and unrestrained conversation where the best interchange of ideas and opinions is effected, where these opinions undergo the profoundest investiga-

tion, and where they are best freed from the prejudices by which they may have been enveloped. These conversations ought to be encouraged and rendered frequent by every possible means, for nothing would contribute more to the discovery and establishment of the truth than the opposition, not of personal feeling, but of legitimate reasoning, and which will naturally lead to a correct conclusion.*

As scientific education will not from its very nature admit of any external constraint, and can only be consistent with an unfettered spirit—and as it is also to be supposed that those who attend such an institution come to it of their own free will, and with the firm determination of acquiring in the most complete manner a thorough knowledge of everything that has relation to Agriculture—constraint would be at once prejudicial and useless. On the other hand, those who come or are sent there with any other view should be removed so soon as it is perceived that they are not identifying themselves with the spirit of the institution, and that constraint alone prevents them from infringing the regulations.—Nevertheless, in such an establishment there must be certain defined rules which must be strictly observed, if only to ensure the general good, and for the liberty and comfort of every one. However great the advantage, and certainly these social communications may forward the general object of the institution, they must not interfere with private application or diligence; and therefore each pupil should have a chamber to himself, and his retirement should be undisturbed.

CAPITAL.

Next to the mental capacity of the person who practices Agriculture, capital is the most important consideration; for, with persons of equal talent, the advantage and success are always in proportion to the capital employed. Therefore, next to the incapacity of the agriculturist, the insufficiency of the capital embarked in Agriculture is the principal cause of its imperfection.

By capital we understand everything that, from the special use by the individual, or from its being placed at the disposal of others, produces a revenue or rent. We do not inquire into its origin, or ask whether it has been acquired by inheritance or by labor.

It is true that generally the term capital is only applied to the possession of certain means produced or amassed by labor, but it is sometimes difficult to determine the share which Nature or Industry has had in the production of certain property—as, for example, in the working of mines and quarries, or of tracts of land recovered from Nature by Art, and put under cultivation; at other times it is more in relation with the actual state of civilization, or where the land is no longer possessed in right of the first occupant, but only in exchange for some other equivalent capital or property, to consider the soil and the produce of the earth as a species of capital. This latter acceptation of the term will give us the clearest idea of agricultural industry.

The immortal Teraus, in his "Political Economy," (Staatswirthschaft,) published by the President of Auerswaldt, establishes, in my opinion, the most correct distinction, when he regards the value of the products of the earth as the wealth of a nation, but as a wealth of which she has not the management. Nowhere have the reciprocal relations of the state of Agriculture and of national wealth been treated in a more lucid and practical manner; and I should have entirely founded my ideas on his if I had read that work before this chapter was composed. It will, however, be easy for every reader to adopt his system. As for the results, we shall judge better of them as we proceed.

According to this arrangement, the capital invested in Agriculture is of three kinds. 1. Funded property. 2. Capital invested in the farm. 3. Circulating capital.

The funded property is that by means of which the agriculturist is put, or may put himself, in possession of landed property. It is the value of the soil, or of property already in, or to be taken into possession. According to general usage, and very properly, it includes the buildings and all the other things appertaining to the soil, as well as the rights attached to the domain, and whether or not relating to Agriculture.

* These remarks of the author may be quoted in favor of Farmers' Clubs—certainly the most effective schools of improvement for the farmer.

The landed capital, or the value of an estate, does not always continue the same. It is frequently varied, either by external circumstances connected with the value of money and of other things, or principally by internal circumstances relating entirely to itself. The modifications of this latter variation in value are called ameliorations and deteriorations. The capital employed on a farm is augmented by the amelioration in the same manner as by the addition of new funds.

The capital invested in the farm consists in the value of the things which are necessary for the exercise of agricultural industry, and is employed in their purchase. It is usually called the *inventory.* Under this denomination are ranged the live stock, and all kinds of agricultural implements and utensils. In some countries they include in the inventory the value of the crops sown, and the advances made for the culture of the following year, and the provisions which remain to be consumed from one harvest to the next. Properly speaking, this latter ought to be considered as a part of the capital which we are next to describe.

The circulating or current capital is that with which the domestics and laborers are paid, necessaries of every kind are purchased, the cattle fattened, &c.; and it consists in a sum of money kept for that purpose, or in an accumulation of produce which is kept to be converted into money.

It is by this capital that the diminution of that which is invested in the farm is supported, and which from its very nature is always deteriorating; and, lastly, from this capital must be derived the necessary surplus for enlarging the funded capital, and for the improvement of the land.

This current capital forms the motive power of the whole concern; it is by its means that all the labor is effected, and it is from this labor, properly speaking, that the profits of agricultural enterprise arise. Hence it happens that, all accidental successes or misfortunes excepted, and supposing, above everything, that the necessary talent and assiduity are employed, the products will always be in direct proportion to this capital.

The funded capital or value of an estate can only be considered as a sum placed out at interest, and on the best security; and it ought to produce the proper rent which can be derived from a capital thus securely placed. Beyond this, nothing more is to be expected.

The capital of stock or of the *inventory,* although we admit that it ought always to be kept up to the same amount by the circulating capital, is nevertheless exposed to more dangers than the former, inasmuch as it is subject to certain accidents, by which the owner runs a great risk of losing, to a greater or less degree, and which has given rise in Germany to the custom of insurance.*

If the interest on the landed capital amounts to four per cent., that of capital employed in the farm ought to be at least six per cent.

The circulating capital is exposed to very great risks; it is the motive power of the whole enterprise, and it requires in the proper administration of it the greatest caution and the most extensive knowledge. For this reason it ought, as the motive power of the whole enterprise, to receive a very high interest, at least 12 per cent.; for it is in this fund that the real profit derived from Agriculture consists.

Consequently, if a farmer cultivates his own land, he should calculate accurately between the produce of the different funds whence his gross income is derived. He should derive an income equal to the value of the money which he expends on his farm, or which he would derive if he sold the farm and placed the money on other securities. It will be the same with the capital on his farm if he parts with it to any other person on the same risks.

It is impossible to fix any general rule as to what ought to be the just proportion of these divisions of capital relatively to each other. That can only be determined in certain particular cases, and by taking all the local circumstances into consideration. The following only can be received as a general rule: that the person who possesses only a small capital will succeed much better as an agriculturist if he keeps the greater part of it in circulation for the current ex-

* Insurance offices for cattle are well known in France; and the agriculturist, in some of the provinces of Germany, owes to them a security which essentially contributes to render the practice of his profession secure, and more easily procures for him the capital requisite for his purposes. The advantages of these institutions appear to me incontestible, if certain prudent and well-advised regulations prevent the too frequent negligence in feeding and in the general treatment of these animals. The Mutual Cattle Insurance Society of London now offers the same security to the farmers of England.

penses of his undertaking, and, consequently, does not invest too much of it in land or stock ;* for the net produce of the enterprise has less relation to the extent of capital than to the means employed in the profitable application of it.

In England, where mercantile calculation and skill are carried to their greatest extent, and pervade every branch of industry and commerce, it is considered that the capital in circulation, in which is always included the stock, should be from seven to nine times the amount of the rent. Whoever takes a farm of £125 rent, should command a circulating capital of from £875 to £1,125. The profits of his speculation, consequently, are not to be reckoned by the rent which he pays, but according to the capital which he can employ ; from which it is considered that he ought to derive 12 per cent. profit, which, for £1,125, would be £135 beyond the rent of the farm. If he is the proprietor, he will first deduct the amount of the rent which he would receive from his tenant if he did not cultivate the farm himself, and then he reckons the surplus as the net profit of his speculation. But he will never draw this false conclusion, that since the cultivation of his estate produces him £260, the actual value of his property is twenty-five times this amount. This example shows the error of imagining that any conclusions can be formed of the actual value of any property from its mere produce, although it enters too much into the estimates of most persons. In fact, they endeavor to conceal this error by another, of estimating this produce at a much lower rate than it should be valued at if under good culture. Nevertheless, this vague and deceptive valuation is too frequently adopted, and the consequences of it are extremely injurious to the agricultural interest.

Even the capital invested in stock, although its augmentation, generally speaking, adds greatly to agricultural produce, may be extended too far, if, by so doing, the circulating capital be too much diminished.

THE FARM, AND THE MANNER OF TAKING POSSESSION OF IT.

He who possesses the necessary inclination, talents, knowledge, and capital, and has devoted himself to the practice of Agriculture, ought in the first place to obtain possession of a farm.

Whoever wishes to obtain a farm ought, in order to obtain it as advantageously as possible, not to confine himself to any one district, or province, or State, but to look around him in every direction. The more numerous the situations which present themselves, the better will be the chance of making an advantageous selection.

That farm should always be selected which, when every circumstance is carefully weighed, promises the greatest net produce in proportion to the available means of the person who is about to take possession of it. We shall never, at least very rarely, find that a perfectly unexceptionable spot will present itself, or which in every respect will realize the anticipations which have been formed. The chief thing is to be able to judge how far its good qualities surpass the bad ones, and to form a right estimate of the whole, balancing the one against the other. In order to make this comparison in a clear and satisfactory manner, the following method may be adopted. The attention of the young agriculturist having been directed to a particular spot of ground, he must make a satisfactory estimate of its value, by applying to it certain general and invariable principles. Afterwards he must study and duly estimate all the accessory circumstances ; he must put a determinate value on the peculiar advantages which may exist independent of the soil ; he must value each, on as exact an estimate as possible. On the other hand, all the inconveniences which are attached to the do-

* The author very judiciously recommends a sufficient circulating capital to be reserved for the expenses of cultivation, and a less quantity of land to be rented, as profit will more generally depend on the mode and success of cultivation, rather than on an extent incapable, or beyond the reach of being properly managed. This is a very general and fatal mistake. The mode of estimating, by the rent of land, the quantity of capital that will be necessary for the cultivation, appears very uncertain ; for land may be worth 20s. or 40s. an acre, and the farmer will require the same implements and animal strength, the same expense to seed an acre of land, the same farming accommodations, and, very often, more expense in many respects. Some differences will occur in particular points ; but a direct ratio between the rent of land and the capital required to stock and cultivate it, has not obtained in our country ; and it would lead to the supposition that good land requires more capital applied to produce a greater result ; whereas it is known that the same means produce the greater result from the intrinsic quality of the soil Inferior lands of certain kinds require more capital than rich soils ; and the allowance of seven to nine times the rent for capital would fall below any average calculation yet made ; and in other cases would far exceed it, except where an extraordinary outlay was required.

main must be considered in every point of view, and the difficulties which will present themselves in every great agricultural enterprise. These must also be estimated, and the sum total found. Then, by deducting one sum from the other, it will be seen how far the actual value of the land, according to its extent and to the quality of the soil, is augmented or diminished by these accessory circumstances.

While money continues to experience so many changes in value, it will constitute a very uncertain guide in determining the positive value of the soil. A much more certain and stable guide, and one of universal application, will be found in the produce; which, because it is of universal consumption, always maintains a uniform and permanent relation with every other commodity. This produce is *the grain;* in Germany principally the rye, and in France the wheat.* Thus, in order to determine the precise value of a farm, it will be much more correct to say that it is worth so many measures of rye and wheat, than so many pounds or shillings. Or if we wish to reduce this fixed value to a numerical one, which may be modified by circumstances, we must ascertain the medium value of wheat with money in ordinary years; and thus we shall be able easily to calculate the sum that a portion of landed property is worth, according to the actual value of money.

The value of a farm consists: 1. In the extent of the whole and of each of its divisions. 2. In the quality of the soil. This latter quality can only, properly speaking, be demonstrated in a precise manner by an analysis of the different substances of which it is composed, and of their physical properties; this, however, may perhaps be done provisionally, or to a tolerably satisfactory extent, by careful observation of the appearance and of the produce of the soil. 3. In the situation, and in the reciprocal relations of its appurtenances. 4. In the exterior circumstances; the prerogatives, the rights, and the charges of the property; or, in fact, in all its accessory and relative advantages and disadvantages.

In the general examination of the land, the growth of the trees and copses, if there be any on the land, their species, their soundness, the elevation of their branches, and the cleanness of their bark, are among the surest marks of the quality of the soil. The plants which grow spontaneously there, even those that are injurious, afford also a valuable indication; but it is not sufficient that they grow isolated and slowly, but, on the contrary, their increase should be rapid and abundant. Thus the corn or *field thistle* (*serratula arvensis*), indicates a rich and productive soil; the butter-bur or great petasites, (*tussilago petasites*), an argillaceous soil; the colt's foot, (*tussilago farfara*,) and the bramble, a marly soil; the common chickweed and pimpernel, (*alsine media*), the common sow thistle, (*sonchus oleraceus*), the charlock, (*sinapis arvensis*), grow on soft and tenacious lands; while the wild radish (*raphanus raphanistrum*), grows in dry and poor lands. The black medick or nonsuch (*medicago lupulina*), is a sure sign of the marly quality of the soil in which it is found.†

An abundant growth of grass, by which persons who value estates often suffer themselves to be too much influenced, is a very deceptive indication, as it is often occasioned by a humid atmosphere or by recent manuring, and sometimes even by the bad state of the cultivation.

The appearance of the crops in an early stage is a no less deceptive sign; for, when they are sown thickly, and in the early part of autumn or in the spring, on a bad soil, they may appear, on a superficial inspection, to be superior to those which grow on a better soil. Sometimes, indeed, the corn is sown in a much greater quantity than it ought to be, for the purpose of deceiving the unwary purchaser.

A far more correct judgment of the quality of the soil may be formed by examining the corn in the ear, or the stubble, provided the examination extends to the whole of the farm, and is not confined to one particular field, on which, perhaps, an abundant crop has been produced by extravagant manuring, or by some

* In Maryland and Virginia it used to be tobacco. The Editor remembers that when a boy, his father's favorite *roan* saddle-horse was wantonly shot by a neighbor on his premises, and the verdict of the jury was for several *thousand pounds of tobacco*—as many as were worth $200. [*Ed. Farmers' Library.*

† Every step indicates the advantage of knowing something of botany. [*Ed. Farmers' Library.*

extraordinary mode of culture which has, perhaps, caused the neglect of some other fields of the farm.

A dark color of the soil after recent ploughing is one of the surest signs of fertility, except in heaths and marshy lands. A dark color of the waters in the furrows and of the deposits taken from them is likewise an indication of a rich soil.

Practice will soon distinguish by pressure of the foot, or by thrusting a stick into the soil, or even by the sensation which is experienced in passing over the ground on horseback, the degree of tenacity in the soil; whether it consists of tenacious clay, or if it be a yielding soil, or whether sand be the principal ingredient. We may also readily judge of the quality by the state of the clods after recent plowing, and from noticing the degree of divisibility or tenacity when they have been some time exposed to the influence of the atmosphere; but more particularly the proportions of the soft clay to the gravel may be easily ascertained by rubbing a portion of the mould between the fingers.

The thickness of the layer of vegetable mould may be easily ascertained by thrusting a stick into it, or by examining the sides of ditches where the ground has been lowered. These last, and also mole-hills, discover the nature of the lower strata of the soil.

The scientific agriculturist, who possesses the most precise and accurate ideas of the classification and goodness of the land, and who understands the different relations according to which it should be examined, ought not the less to be acquainted with their ordinary classification, and with the names by which practical men are in the habit of ranging and distinguishing them, whether generally, or in particular districts, in order that he may not be at a loss when he is treating for the purchase of property of this description.

The division of land into good, middling, and bad, is general and natural; but it is purely relative.

Tenacious clay has been often ranked in the first class; and a lighter soil, and even calcareous earth, in the second. Other persons have given the preference, and very justly, to the latter, because, in the cultivation which is associated with pasturage, more regard is paid to the soil which best promotes the spontaneous growth of the herbage; while in the former the growth of corn is the only object regarded.

Sometimes a signification similar to the above is given to the comparative expressions, *heavier* and *lighter;* but these terms are then merely used to denote the tenacity of the soil and the degree of resistance which it offers to the plow and the harrow.

Sometimes the land is classed according to the number of times the seed is multiplied by vegetation in the course of tillage followed in that part of the country; and thus it is called 3, 4, 5, or 6 seed land. Sometimes the seed itself is included in this calculation; at other times it is necessary to become acquainted with the relative quantity of seed that is sown and whether equal quantities are sown on equal areas of different lands, in order to be able to draw some conclusion from these data; but the produce generally depends more on the quantity of the manure than on the nature of the soil.

One of the most useful modes of classification relates to the description of grain which the land has produced in the course of the established succession of crops, and that, generally, in a period of three years; and likewise to those which it is supposed to be able to produce with the greatest advantage. The following is the classification usually adopted in Germany:—

1. *Wheat land;* that which after a fallow produces wheat with more profit than rye. If, in the course of the triennial rotation, it cannot bear wheat twice in six years without being manured more than once, it is called—

(*a*). *Rich Wheat land;* which is found only in places of alluvial deposits and in low situations, where the rivers have deposited the mud.

(*b*). *Ordinary Wheat land,* if it can produce wheat only after having been manured, and after having lain fallow; and the second time, without manuring, rye only.

2. *Barley land.* In this and the following class no attention is paid to the first or winter crop, but only to the second or spring crop. Here are also distinguished—

(*a*). *Rich Barley land;* that which twice in six years produces barley after

the winter crop, with only one manuring. Many persons, believing that land of this nature can produce wheat equally well for the first crop, include it in the same class with the wheat land. Others, with more reason, draw this distinction, that a soil is often exceedingly well adapted for the production of barley without being well suited to the growth of wheat, and will often bear rye with more advantage. On the contrary, an argillaceous soil, which is better adapted for wheat than for rye, is not so proper for barley, and will, with much greater advantage, be cropped with oats for some one of the second crops.

(*b*). *Poor Barley land;* land in which barley will not thrive as a second crop without manure, but which, in the second rotation of crops, may be made to produce oats, though not very abundantly.

Where the large and the small kinds of barley are both cultivated, the lands which produce the first are called *large barley lands;* and the others, the *small barley lands.*

3. *Oat land* is that which produces oats after the harvest of the winter grain. Strictly speaking, only cold and heavy land may be included in this class; and every other soil which yields oats with advantage might, with good tillage, be made to produce barley with equal profit. In general, however, we include under this class, lands which are considered too light, or which have too little consistence for the growth of barley. This class includes—

(*a*). *Rich Oat land*, which, with only one manuring in nine years, yields oats after each winter crop, and, therefore, three times during each succession of crops.

(*b*). *Middling Oat land* which is allowed to lie fallow the eighth year after it has been manured.

(*c*). *Poor Oat land,* which, under the same circumstances, yields but one crop of oats.

4. *Rye land,* which, in the three years' succession of crops, produces rye every third year only, and which has not sufficient strength to produce another kind of grain, and, consequently, must lie fallow for two years.

The names of *sixth, ninth,* and *twelfth years' rye land* is applied to that kind which produces this grain only every sixth, ninth and twelfth year, and lies fallow during the rest of the time. To this class belong those exterior and distant parcels of land which are never manured, where bad quality does not arise so much from the nature of the soil as from the want of manure. The substance which nature affords to such lands by the growth of the grass and from the dung of the sheep that eat the herbage, is quickly absorbed by the rye crop, and thus the land returns to the original exhausted state.*

However vague this classification may be, it is, nevertheless, the most precise and definite of those which are in general use; it is, likewise, that which is employed as the basis of most valuations. The agriculturist, whose judgment is guided by the most accurate knowledge of the nature of the soil, ought not to be ignorant of it; and he ought, also, in every country to which his fortune may call him, to examine most minutely the physical and chemical properties of every soil, and arrange them under their respective classes.

Every intelligent farmer will be guided in the choice of land rather by the quality of the soil than by the extent of the property; for the want of fertility can seldom be compensated by an increased number of acres. There are farms which are absolutely worth nothing, and which, when every thing is taken into account, never repay the expenses of cultivation; and, consequently, for the growth of corn, a thousand acres of such land are not worth so much as a single acre of good land.

The greater the general fertility of a country, the less is the value of the bad land it contains; for the produce, or the yearly value of the richer land, will diminish the rent of the poorer lands in the neighborhood. Where the produce of the fertile portion of the land satisfies every want, the soils which are less productive can scarcely be cultivated with advantage. If, on the contrary, the more fertile lands do not produce a sufficient supply for the usual consumption of the district, the cultivation of the others will become more profitable; and conse-

* By land lying in fallow, the author here means a state unoccupied by arable culture; for he mentions the grass sward, and the dung of sheep as being absorbed by the triennial crops of rye, and that the land returns to its originally barren state. This mode resembles the old out-field system of Scotland.

quently, a higher price may be given for inferior land in a poor country than in one which is highly productive.

Next to the arable portion of the farms, the meadow land should come into serious consideration. A due proportion of meadow and arable land has hitherto been considered as an essential requisite in a good farm; and that a quantity of land, although composed of the richest and best soil, would be defective if it was not accompanied by a sufficient extent of meadow ground. This opinion is founded on the acknowledged fact that without a sufficient supply of green food no good tillage can exist; and also on the acknowledged axiom, that without meadows there can be no forage. Yet, when it shall come to be generally known that by cultivating the various grasses, and by alternately using the different portions of the land as arable land and as artificial meadows, three or four times as much nourishment can be obtained for the cattle as on the same extent of natural meadows, the deficiency of natural meadow land will no longer be regarded as a defect in an estate, the soil of which is tolerably fertile, and in which the rotation of crops is at the disposal of the farmer.* Nevertheless, this circumstance ought only to be considered as placing some limits to the supposed value of good meadow.

The value of meadows is, perhaps, more difficult to be determined than that of arable land; and fixed rules for the determination can only be laid down when in a portion of this work the cultivation of pasture land is taken into consideration. In most valuations they are divided into three classes—good, middling, and bad; but this division is not sufficiently precise for the correct valuation. The known or estimated produce, and the quantity and value of the hay, would be a better guide; but both the quantity and value vary exceedingly in different times and places. Therefore, the meadow land is divided into five classes; the produce of the first and best being calculated at 30, the second at 20, and the third at 14, the fourth at 10, and the fifth at 6 hundred weights of hay per acre. Particular attention must, however, be paid to the more or less frequent occurrence of circumstances; meadows usually the best watered, being exposed to inundations just at the very time when such an accident will effect the greatest damage. According to the ordinary mode of valuation, meadows are estimated at a price improperly compared with the quantity of hay which they are known or believed to produce. This value arises from the charge for grazing cattle being likewise fixed at too low a rate. Thus, as frequently happens, an attempt is made to conceal one fault by another and a worse.

The purchaser, agreeably to the knowledge which he has acquired of meadow lands, and of the ameliorations of which they are susceptible at a certain expense, should make an estimate for himself of the advantage which he believes he may derive from it according to his peculiar mode of using it, and from the ordinary market price of the country. He should carefully and personally inquire whether the meadows are exempt from the right of pathway through them; whether they are subject in spring or in autumn to any right of grazing upon them, or any other ancient servitudes; and also whether he can, at his pleasure, irrigate any and what portion of his meadows, or whether he is subjected to any restrictions on this point.

Cattle may be fed: 1. On open spaces, or spots but thinly covered with trees. 2. On fallow lands or in the stubble of corn-fields. 3. On meadow lands in the spring, and after the first and second mowing. 4. In woods and forests. 5. On marshes.

The valuation of woods is attended with great difficulties. This valuation may be made under very different circumstances, and, consequently, may be attended with very different results: it may have relation to the return which the woods might yield if kept in good order, according to the principles of forest cultivation; or to the sum which might be realized from the quantity of timber actually growing on the land, supposing that the whole or a part of this timber could be profitably disposed of; and also taking into consideration the profit which might be derived from the land thus cleared by converting it to a different use.

* The author steers a middle course in opinion between arable and meadow lands in point of utility. He thinks a knowledge of the alternate system ought to set a limit to natural meadows, but not to annihilate the value, or rather the supposed value. That system will require much time to force its way even with enlightened minds.

The difference between the results of these modes of valuation is enormous, especially if the calculation be made according to the method adopted with those which are national property. According to the principles adopted in many estimates, the value of the land would be increased by entirely clearing it of wood and converting it into pasture grounds for sheep.

Timber for building, for other purposes, or for fire-wood, always adds to the value of an estate; particular attention should therefore be paid to it in the purchasing of land.

Many persons, when about to purchase an estate, place great reliance on the information which they collect from the occupiers of neighboring farms, or from persons known in the neighborhood, and even on that which they obtain from the laborers, shepherds, and tenants. Such persons may, it is true, be capable of furnishing useful information; but it would not be prudent to place too much reliance on their reports without testing the correctness of them by actual observation. He who seeks to spare himself the trouble of personal examination, runs great risk of being deceived. Such reports as those referred to are so much the more suspicious in proportion as landed property has become an object of traffic in the country, and has passed into the hands of speculators, particularly those who are connected with mercantile or agricultural companies. The tricks which have been resorted to for the purpose of deceiving purchasers are almost incredible, falling not far short of those practised by horse-dealers. In countries of this character, it will be prudent to regard all those who furnish you with information as tools of the seller. Even written documents, leases, and registers, can scarcely be trusted without some convincing evidence of the truth of their contents.

Sometimes the last owners have sunk large sums of money on an estate, and have considerably augmented the fertility of the soil, but they have not had sufficient perseverance or sufficient good fortune to enable them to reap the benefit of their exertions; and there have been instances in which the improvements have been made on a farm, but it has been left to the successors to enjoy them. On the other hand, the last occupiers may have contrived to reap considerable pecuniary advantage from the use of the property by exhausting the land, and thus improved their own fortunes at the expense of the estate. A farm may thus acquire a good or a bad reputation in the opinion of those who only take a cursory view of it; and this will, in the former case, attract a great number of purchasers to the sale, or, in the latter, keep them away, and thus cause the estate to be sold at a price considerably above or below its actual value. This must not, however, be taken as a general rule; for a needy or a careless occupier may have derived only a scanty amount of produce from the land, and yet have impoverished it to an extent which will render the employment of a very large capital necessary to restore it to a state of fertility.

Estates often possess considerable resources which have escaped the notice of lazy or ignorant farmers, and have, consequently, never been turned to account; and such estates are likely to yield much more than those which have been in the hands of competent persons.

The gross produce of each harvest on a given extent of land having been determined, the net produce may be calculated from it, and for this purpose the quantity of seed sown must first be deducted.

When a calculation of the total amount of the produce has been followed by that of the expenses attendant upon each harvest, it is also customary to deduct the price of the quantity of each grain consumed on the estate, (such, for example, as the quantity of wheat and rye for bread, and of barley for beer, &c.) as also the wages paid for threshing the corn. There appears to me to be an unnecessary prolixity about this, since the value of the corn required for consumption on the farm might be more correctly joined with the other expenses of the household, and the result thus obtained would give a much clearer idea of the whole. Besides, it is sometimes necessary to purchase certain kinds of grain, such as oats, for other purposes.

In order to avoid the very troublesome calculation of the expenses of cultivation, attempts have frequently been made to subtract a quantity of grain from the gross produce, in order to cover these expenses and also those of the home consumption. It is evident that this method is exceedingly indefinite, and that it must be considerably modified by time and place.

The term of "*rent or farm grains*" is given to that portion of every kind of seed which remains after deducting the seed sown and the expenses of cultivation, and they are valued in money as constituting the net produce of the culture.

Or, again, the lands comprised in the same class in the register of mensuration or cultivation, may be collected together, divided into three equal parts, and their value arranged in the form of a table.

When there are fields, enclosed by hedges, near the house, they are usually valued separately, not according to the quantity of seed sown in them or the crop which they yield, but according to their extent. Thus, an acre of such land is valued at a much higher rate than an acre of unenclosed land. In the official returns it has even been raised as high as from three to six rix-dollars, although the soil in itself cannot be considered as much better than that of the rest of the land. The more careful tillage, the large quantity of manure with which they are enriched, the right of enclosure, that is to say, the being able to dispense with herding, and the greater quantity of produce which they afford, give a high value to these enclosures in the opinion of most persons.

Kitchen gardens are also valued in proportion to their extent, and at rather a high rate. The great produce derived from them is, however, for the most part due to superior cultivation. The same remarks also apply to hop gardens.

Vineyards are valued according to the amount of the produce. The knowledge of this produce is acquired by practice, and in a manner which it is hardly possible to teach by rule; because the properties of the vine and of the soil, and the influences of climate and aspect, have not as yet been satisfactorily ascertained.

Orchards and fruit-gardens require particular attention in point of climate and soil most suitable to fruit. In some countries a good crop may be reckoned in every two years, while in others a good crop can scarcely be obtained once in nine years. In the former there are usually large plantations of fruit trees, and their average produce indicates with sufficient exactness the price which should be put upon them; in the latter, after having determined the value of the soil, the trees should be estimated only in proportion to their size, vigor, and kind, unless the plantation possesses a certain aspect and situation, be protected from hurtful winds, and contain only trees of a choice kind and of good quality; under such circumstances an orchard may be particularly valuable, even in a climate otherwise unfavorable to fruit trees.

As to the expenses of cattle feeding, the principles by which it is determined must, of necessity, be uncertain and subject to variation. In estimates founded on the triennial succession of crops, it is reckoned at scarcely half the value here assigned to it.

In ordinary estimates, the annual cost of a cow is reckoned at from three to ten rix-dollars. But it seldom reaches ten rix-dollars on estates managed according to the triennial succession of crops; and is only found in places where the meadows lie low, are fertile, and well watered. A third part of the stock are considered as *élèves*, (young cattle,) and each of these is valued at the sixth part of the price of a milch cow. It is, however, admitted that pastures beyond the estate are available for the nourishment of young cattle, and then the produce of one out of two is only taken into account.

Sheep are valued at from twenty to thirty rix-dollars per hundred, and their grazing on sheep walks is not taken into account. Although the profit of sheep husbandry has been allowed to be infinitely greater, it has not been thought necessary to raise the estimate, on account of the great risks from mortality that have hitherto occurred. And in the net produce of sheep feeding, much is undoubtedly attributable to care and industry.

The profit of pigs is sometimes estimated according to the number of cows, and sometimes according to the extent of the grain crops. In the former case, it is considered that for every cow a pig may be kept, which is valued at from eight to ten groschen;* in the latter, one groschen is reckoned for every bushel of winter grain as the value of the feeding of pigs on the stubble. On the other hand, the expenses of feeding poultry are estimated by the extent of the spring sowings; and six groschen for every bushel of seed are allowed for that purpose.

Hunting and fishing can only be estimated according to the locality, or from

* A groschen is 1½d. English money.

experience, or from general usage. The valuation of fish ponds requires a peculiar kind of knowledge, which we cannot explain in this place.

Lastly, we have to estimate the value of the statute labor—or that which the tenant is obliged to perform for his landlord without remuneration. This is divided into—

First, statute labor performed by draught cattle and by manual labor. The first kind of statute labor is, for the most part, due only from those estates which were originally sufficiently extensive to require a team of cattle or horses. The other kind is due from small farms, which either are not or were not sufficiently large to maintain teams. Statute labor, by horses, is divided into that which is performed by four horses, and that which is performed by two or only one. As for manual statute labor, it is sometimes due from persons who do not possess any arable land, but merely a house or garden, or some pasture grounds.

Secondly, into fixed and variable statute labor.

The former is usually limited to a certain period of time, so that the person from whom it is due is obliged to furnish a certain number of days' work per annum. The choice of the time when the work must be performed does not often rest with the owner of the right; the days are more generally fixed in some particular weeks in each period of tillage; sometimes there is a certain amount of each kind of labor appointed for the day, and, at others, the amount is left indefinite. In the latter case the owner of the right derives a very trifling advantage from it, which is much reduced if he has not the power of enforcing the performance of the work, as is the case in places where hereditary service and vassalage have been abolished; and which will be still more the case when hereditary jurisdiction shall have ceased. This statute labor is, in such cases, far more injurious than any other species of servitude, both to the individual who is subjected to it, and to the public good; because it creates idleness and carelessness, intentionally bad performance of work, and a highly reprehensible degree of insubordination; and is thus destructive of morality, and occasions the loss of much valuable time and labor. The servant, or the son of a peasant, is encouraged by his master or his father to be idle, negligent, and deceitful; he considers it as a point of honor to cheat the landlord; he thus becomes habituated to idleness, and then goes on to deceive his master or his father, and himself, by losing the habit or the power of working up to his strength.

From this cause men are found to be more idle in situations where statute labor is established than elsewhere; and the servants in such places imitate the idleness and dishonesty of those who are subjected to this right. For the same reason greater profit is derived from that statute labor, the amount of which is fixed for each day; and it is advantageous to relinquish a considerable number of the days of service in order to obtain this fixed mode.

Sometimes the statute labor consists in a certain quantity of work of a particular description, without specifying the number of days. Under this arrangement the work is certainly more quickly done, but it is not done nearly as well. When all the fields appertaining to an estate, or only a portion of them, are cultivated by statute labor of this kind, they may easily be distinguished by the scanty crops even from the lands of the peasants; and notwithstanding the advantages resulting from considerable tithes and extensive pasturages, they often yield a very poor return. In such districts, lands thus cultivated may be distinguished, even by a very casual observer, from those cultivated by the servants and teams of the proprietor. The difference in the produce amounts to far more than the value of the statute labor.

If, then, the amount of the labor is to be fixed, either by the day or by the aggregate, the best mode of proceeding is to make choice of work, the manner of executing which shall not cause any sensible difference; and thus, as far as possible, it is desirable to use carts and wagons, the loading of which can be determined with tolerable precision.

Undefined statute labor appears to be only compatible with the condition of the peasant, whose house, farm, and cattle, are the property of his landlord; who has thus the right of continuing or withdrawing them at his pleasure. In this case the peasant must be literally regarded as a servant, who is allowed the use of the farm in lieu of board and wages. The landlord will not, of course, over-work either the peasant or his cattle for fear of injuring his own property. This ar-

rangement may take place independent of vassalage or hereditary servitude, the parties having the option of canceling their mutual engagements at the termination of a specified time, if they find it advantageous to be done. Statute labor of this nature, still exists in places where the peasant is really the owner of his farm. In such cases unreasonable demands are restrained by the principle that the peasant ought to have sufficient time allowed him to sow his own land, and cultivate his own farm; but as the decision of disputes which may arise on these points is attended with infinite difficulty, law-suits and misunderstandings without end arise, the annoyance of which is scarcely compensated by the advantages which may be derived from such services. Personal statute labor is sometimes regulated by the day, and sometimes by the quantity and nature of the work. To the latter kind belong, particularly, the seed time and harvest statute labor, in which any certain person has to execute a fixed quantity of work. In daily statute labor, it is frequently not specified whether the work is to be done by a man or a woman, by a strong or a weak person. But as it is generally performed by persons who are otherwise most frequently employed on the estate, and who are, consequently, more dependent upon it, and sometimes also by tenants, who pay their rent in this manner, greater advantage may be expected from it than from statute labor by horses; and it may, without risk of error, be estimated at the value of a woman's day's work. This kind of service is likewise less burdensome to the individual from whom it is due. In some places it is the established custom to have the entire harvest gathered in by labor of this kind, in return for which the laborers receive a certain portion of the crop, and after the threshing, a second remuneration in grain.

However advantageous this practice may have appeared, the inconveniences are now fully appreciated in Lower Silesia; not so much on account of the excessive quantity of the produce which the laborers receive, as from the irregularity and carelessness with which the harvest work is performed. These hereditary harvest laborers are now regarded rather as a burden than an advantage to an estate.*

Another important point to be attended to in the purchase of an estate, is the relative position of the lands of which it is composed. In some countries the division and mingling together of properties of various kinds, and belonging to different parties, is almost universal. When the partitions were first made, the method of dividing a given extent of surface into any number of equal portions was unknown; that ignorance was undoubtedly the cause of this dismemberment of estates; it may, however, have arisen partly from other considerations, which were then of more consequence than the appropriate situation of a field. At the present day, where this excessive division of the estates cannot be modified, it totally precludes the possibility of bringing the land to any degree of fertility. The cultivation of such land is subjected to a number of difficulties and annoyances, and the small portions of it can never be so well cultivated as the larger. Great loss of time is occasioned by the fields lying apart from one another; and besides, such a division of the land renders it impossible properly to overlook the workmen, or maintain a fitting control over them; neither can an exact account be kept of the work that is done; nor can the time and labor which will be required for tilling and sowing the land be previously determined. The separation of the fields by ditches occasions the loss of a considerable quantity of land; and yet these ditches are necessary if we wish to have the boundaries preserved inviolate. Moreover, without the concurrence of his neighbors, the farmer is unable to effect the destruction of noxious weeds; and proper enclosures, which are often so useful, become impracticable.†

On this account, detached portions of land, as those in question, are, in the opinion of experienced agriculturists, scarcely of half the value of those estates where lands lie together, and which the proprietor can use without restriction. An experienced agriculturist will, therefore, always decline purchasing an estate consisting of detached portions, unless he has a fair prospect of being able to

* The disadvantages of statute labor of any kind are here treated at length, and the total abolition is very earnestly urged. The late commutation of road labor in England may be regarded as the last vestige of that injurious system. Many remnants of it yet remain in the northern parts of the kingdom, but are gradually falling into disuse.

† How perfect a picture of the evils of our common field system!

make some exchange, and so unite a considerable part of his land in one tract; and enclose it, and enjoy the full and entire control.

When an estate is composed of contiguous portions of land, or, at least, contains enclosures, or considerable pieces thus united, it is then necessary to consider it as a whole. The nearer it approaches to a circular or a square form, the more commodious it will be; a long and narrow strip of land is very inconvenient, and is not easily and suitably apportioned to the successive crops.

Another important subject of observation is, that the buildings belonging to the farm should be, as nearly as possible, in the centre of the property, and at an equal distance from each portion of it, if the lands can be so divided that they shall all immediately surround the buildings, and that the remotest part of one field shall not be more distant than the remotest part of another.

Injudiciously situated farm-houses, barns, &c. &c. are but too frequently met with on estates, because, at the time of the erection of the ancient chateaus, convenience in tillage was the last thing that occupied attention; and, latterly, entire farm-houses have rarely been erected, but merely a few isolated buildings, which have been, for the most part, placed on the same spot as the old ones, in order to be in accordance with those already erected. This evil can seldom be remedied, except by the erection of entire new farmsteads; and there are not often sufficient motives to induce such a determination. This is a point to which particular attention should be paid when purchasing an estate.

The roads which lead from the buildings to the land, or from one part of the estate to another, should also be carefully noticed; since, if they are badly contrived, rough, and circuitous, they will occasion a great waste of labor and of time. The purchaser of an estate must not forget to calculate the alterations and repairs which these roads may require.

A judicious arrangement and due proportion of farm buildings is a valuable feature in an estate.

The farm buildings are generally omitted in a valuation, being regarded as a necessary part of an estate. But the purchaser should not fail to regard their being out of repair, badly situated, &c. and the expenses necessary to remedy these evils, as very disadvantageous circumstances.

Good and substantial buildings should always be considered as having a certain value, although he who calculates the interest and compound interest of his outlay, may not be inclined to include them in his valuation.

A plentiful supply of good water in the farm-yard, and in every place where it can be turned to good account, is a matter of great importance; and the advantage of which is rarely appreciated, excepting where it is wanting.

Perfect equality or resemblance in the arable lands, provided that the soil is tolerably moist, and easily worked at all times, facilitates the distribution of the portions of land appropriated to the different crops, and, consequently, the whole management of the farm. Numerous and considerable variations in the nature of the soil create and give rise to considerable difficulties in the choice and distribution of the various successions of the crops, and which require more than ordinary experience and sagacity to overcome. If, however, the soil be of a bad quality, it is desirable that the defects should be in opposite extremes. If one part of the land consist of clay, which is so tenacious as only to admit of tillage in that dry state of the atmosphere which is never of long duration, it is important to possess a proportionate extent of light soil, which may be worked in any state of the weather; and this land, in such cases, acquires a peculiar value, because it affords employment for the laborer and the teams when the state of the argillaceous land will not admit its being tilled; and, therefore, when the favorable degree of temperature arrives for working these latter portions, the farmer is able to expend on them a greater proportion of labor and care.

Among the circumstances which determine the relative value of an estate, the commercial relations, and every thing connected with them, demand especial attention. In this respect, the geographical position is of great importance. The neighborhood of large towns may double or triple the value of the soil to an agriculturist who is inclined to speculate, and who knows how to turn it to account. The greater or less distance of the principal market-towns and sea-ports may also considerably affect the value of the land. In most valuations, the price of corn is usually regulated by these circumstances. Communication with these mar-

kets and sea-ports, by means of canals and navigable rivers, or, at all events, by good roads, which are always passable and not encumbered with heavy tolls, diminishes, as it were, the distance of an estate from them, by lowering the expense of transporting the produce.

The demand for different kinds of produce is infinitely more advantageous to an experienced agriculturist than that which is confined to a limited number of varieties. He is then able to apply his land to the growth of all the various kinds of produce for which it is adapted—to intermix them and let them succeed one another at more distant intervals; whereas he is much more restricted if the demand be limited for grain alone. In most cases a high price of *live stock* is far more advantageous to the farmer than a high price of corn, because he can raise a proportionally greater quantity of live stock than he can of vegetable produce for the market; the latter being in part, at least, consumed on the land, and the price of labor is regulated by the price of corn rather than by that of flesh, wool, &c. But special attention must always be paid to the most economical way of procuring the manure which so materially affects the growth of plants and of vegetable produce.

The constitution of a country, and the principles by which it is governed, have likewise an important influence on the value of an estate. A firm, precise, and intelligible code of laws, a simple and expeditious form of conducting law suits, and a rigidly impartial administration of justice, tend to raise the value of property in the opinion of every reasonable man.

A well devised and efficient system of domestic and rural magistrates and police, which affords protection against thieves, and, as far as possible, guards against every kind of danger; which lightens the duty of assisting the poor, and although obliged to supply the want of public spirit by coercive measures, yet abstains from the imposition of vexatious imposts; which, disregarding all antiquated prejudices, acts upon reasonable principles and not upon ancient forms; and which is, finally, more solicitous for the establishment of order than for the profit arising from the settlement of disputes; such a magistracy and police cannot be too highly valued. A consistent and rigorously observed system for the regulation of servants is also peculiarly important.

A government which recognizes and adopts this principle, viz: that the improvement and culture of the soil to the highest possible degree, contributes more than any thing to the welfare of the country, and to the strength and riches of the State; and that all other considerations of political economy must, therefore, yield in importance to the necessity of promoting the increase of produce; a government, which recognizes and acts upon this principle, will, by so doing, add considerably to the value of land, and induce foreigners to invest their capital in it.

The more numerous the population of a country, the greater is the value of the profit to be derived from the cultivation of the land. These advantages are, however, greatly influenced by the nature of the population, the power and relative proportions of the classes of which it is composed. A large population in towns is highly advantageous to the agriculturist in a mercantile point of view, as it ensures the demand for a great quantity and variety of provisions.

Property, or land, is either absolute, acquired by inheritance, or purchase, and is then called patrimonial, or freehold; or it is limited, as is the case with that in which the occupier has a life interest, or holds by a long lease, or an hereditary lease, or in various other ways sanctioned by custom. The restrictions on the free disposal of property of the latter description are many and various; in different countries, and in different provinces of the same country, they will be found to be more or less burdensome and oppressive. Before deciding on the purchase of an estate, all possible information should be obtained respecting the origin of these restrictions, and the laws and usages which relate to them. But since, at the present day, most governments seem to be aware of the great inconveniences that arise from restrictions on property, there is a prevailing disposition to abolish them and to enfranchise all estates by the substitution of fixed duties. Such a measure will restore a value to many properties which they had almost totally lost, and which will contribute greatly to general convenience.

There are a number of particular rights to which an estate may be entitled,

or to which it may be subject, and which must, therefore, be taken into consideration in forming a valuation of it; as, for example:—

The right of cutting timber (*droit de bochérage,*) or of taking wood for building, repairs, or firing, from the forest of another party. This right is sometimes unlimited, as regards the extent to which the owner may avail himself of it; at other times it is more or less restricted.

The right of mast (*droit de glandée,*) or that of feeding pigs in another man's forest. This right is also frequently unlimited; but it is generally restricted to a certain number of animals. It usually does great damage to the forest.

The right of way (*droit de passage,*) which confers the privilege of demanding a road or path through the estate of another, the direction of which may either be fixed, or removable by the will of the proprietor of this right. The breadth of the carriage road should be eight feet, and, where any windings occur, ten feet; and it must be wide enough to give a free passage to a harvest wagon.

There are also simple rights of pathway (*droits de sentier,*) which are sometimes very expensive and burdensome to the proprietor, and the establishment of which ought, therefore, to be strongly opposed.

The same may be said of the rights of pasturage, and of watering cattle on another man's estate (*droits de pacage et d'abreuvage,*) which often hinder or prevent the cultivation of a considerable extent of ground.

The rights of conducting and using water (*droits de passage et d'usage d'eaux,*) give to the owner the privilege of making arrangements for water-courses, drains, ditches, and sluices on the lands belonging to another, and care ought to be used that they shall not occasion greater damage or inconvenience to the proprietor of the estate than the nature of the case renders indispensable. With regard to the right of turning waste water upon a neighbor's land, the provincial regulations vary exceedingly. This often makes a very great difference in the value of an estate, because it may be rendered healthy or unhealthy, according to the manner in which the right is exercised.*

The most minute examination of all the details of these privileges and restrictions would be inadequate to the determination of the exact pecuniary value of an estate; such an examination may, however, serve as a guide respecting the expediency or inexpediency of purchasing some particular estate. After having determined the value of the land, independent of all other or secondary considerations, it will be best to proceed according to the method proposed in a previous page, to estimate every other advantage or disadvantage, in order to add or deduct its value; and an opinion may then be formed with regard to the expediency of giving more or less for an estate than the intrinsic value of the land.

Leasehold Estates.

The second manner in which a person may get possession and hold an estate, is by *lease*. This is the purchase of an estate, or of its produce, for a certain number of years; it relates to purchase in several ways. The search for an estate suitable to the means and industry of the farmer, and the examination and estimate of its qualities and value, should be conducted in the same manner. But there are considerations relative to farming, which are not only different, but totally opposed to these directions. There the proprietor directs or ought to direct all his efforts to the obtaining and continually increasing the quantity of produce, or to the constant augmentation of its real value. The farmer can have no aim beyond obtaining the greatest possible amount of produce during the term of his lease, without troubling himself about the value of the land after its expiration. While the proprietor may content himself with a scanty produce during the first few years, with the view of securing a larger and more permanent crop in future, the farmer must, on the contrary, endeavor to obtain the largest possible crop, even at the risk of diminishing the amount of produce during the latter part of his lease. The proprietor who acts the part of a prudent agriculturist, derives both pleasure and profit from applying all the capital and means which are at his disposal, to his estate; whereas the farmer draws

* The different rights and burdens on landed property enumerated by the author as being hurtful and injurious, are as many remnants of feudal ignorance, and are now, or ought to be, abolished in all enlightened States.

from the estate all the capital and profit that he can, in order to employ it elsewhere, or place it out at interest.

The proprietor delights in improving his estate; the farmer only endeavors to augment his fortune.

The longer, therefore, the term of a lease, the more nearly will the interest of the farmer coincide with that of the proprietor; and the shorter the term, the more widely will the interests of the two parties diverge.* A farmer who holds a lease for twenty-four years will, if he acts prudently, follow the same course for at least the first two-thirds of his lease, as would be pursued by the proprietor. But the time will arrive when he will be guided by totally opposite considerations, and will be obliged to draw from the land precisely in proportion to the money which he has previously expended upon it.

Besides, we must recollect that the farmer has not the means, even if he has the will to do so, of expending so much upon the land as the proprietor himself. He must pay his rent every year; while the landlord who enters with spirit into the undertaking, can save something from the net profit to expend upon his land. The former may be compared to a merchant who trades with borrowed money; the latter to one who speculates with his own capital. The former must make his being able to pay the interest of what he has borrowed, the first consideration; the latter may think of extending his commerce and undertakings by new speculations.

It is not, then, to be expected from a farmer whose tenure is very short—nor, according to the principles of his occupation, can it be required of him—that in the cultivation of an estate he should act as if it were his own property, or sacrifice any part of his profits, even for the sake of improving the land very considerably.

For these reasons it has been thought necessary to impose certain conditions on the farmer, which may restrict him in the management of his farm, and compel him to conduct it in such a manner as shall contribute to the improvement of the land. But the drawing up of such contracts is an exceedingly difficult matter; so much so, that there is, perhaps, some reason in the assertion, that if all the most skillful lawyers and best agriculturists in the country were to meet together, and be employed for a month in the formation of one single farming lease, they would not be able to concoct one which would secure the estate from the deteriorations caused by a bad farmer, without making the contract such as an honest man could not accept. If the conditions were too precise and binding, a man who united prudence with honesty would reject them: he would leave the farm to be leased by some simple-minded individual, or by one who has his own peculiar mode of going to work.

Even if the rent of the farm should be such as to enable him to observe these conditions, the farmer would, nevertheless, find all his exertions fettered, even those which he might be willing to engage in with a view to the improvement of the land; for in every undertaking, even the most useful, which might deviate in the slightest degree from the line of conduct marked out for him, he would be in danger of subjecting himself to censure and legal processes.

On the other hand, a farmer who is satisfied that, by keeping to the letter of his contract, he can save himself from being prosecuted in a court of law or condemned to pay damages greater than his profits, will always be able to evade the conditions of a lease filled with legal precautions, especially if, in laying down the conditions, the greatest possible care has not been taken to attend to the peculiar circumstances of the estate. He will always find the means of evading oppressive conditions and restrictions, or of securing compensation for the fulfilment of them in some manner still more detrimental to the property.

With the view of placing in a clearer light the maxims by which dishonest farmers are in the habit of regulating their practice, and of putting those who let farms on lease on their guard against them, we shall here transcribe *the golden alphabet of the farmers who have placed themselves above the laws of duty and honesty.*

1. Above all things, look out for a farm which has been brought into good condition by proper and improving cultivation, or by having had its resources but

* The author's views of leasing land are most just and liberal; for the nearer the holding of land by the farmer is assimilated to that of the land-owner, the closer will the interest of both parties be associated.

little exhausted. For such a farm you may, in proportion to its extent, pay double the rent, for a small number of years, which you would give for one which has been impoverished by an avaricious agriculturist or by industrious farmers. In the former you may employ the utmost refinements of the art of exhaustion; whereas, in the latter, you will be obliged to adhere to the ordinary mode of proceeding.

2. If possible, cultivate no grain except for sale; do not raise anything for the consumption of cattle, because they do not immediately pay the expenses of better feeding, and you would not be able to derive the full advantage of the quantity of manure which you would have put on the ground during the short term of your lease.

3. Among the fallow crops, cultivatè those only which produce the greatest profit in money, as flax, tobacco, seeds which produce oil, &c.; and if you cannot undertake their cultivation yourself, let the ground to the poor people in the neighborhood who will pay you partly in money and partly in produce. Never mind if they do not give you any straw, for the farmer is generally prohibited from selling it, and at all events you could not venture to sell it openly in large quantities.

4. As these crops require a great deal of manure, and you will every day obtain a smaller quantity of that article, content yourself with raising them on those fields which are in the best state of cultivation and at the smallest distance; and thus the cartage will occupy less time. Even if the other fields should be unable to produce anything during the latter years of your lease, you will be sufficiently indemnified for this miscalculation; and you will have a right to complain of the sterility of the soil, and to demand a reduction of rent. Besides, the nearer portions of the land are most likely to be noticed by the landlord and by strangers; and if any one should say that flax, rape and tobacco exhaust the land, you have only to appeal to the fine wheat growing close by. Never expend manure upon the fields which are most in need of it, for poor land never pays the expense of the first manuring; you can, however, put a little on the sides of the fields, and near to the pathways. In the last year of your lease, apply the manure as much as possible to the spring crops, because you will reap those, but you will not reap the autumnal crop.

5. During the first few years, give the land the best possible tillage with the plow, the harrow, and the roll, in order to destroy all noxious weeds, to bring the manure which the soil may already contain into action, and to divide the clods so that the roots of the plants shall find nourishment in them. Therefore, increase your teams, and you will be repaid for the outlay before the expiration of your lease. But towards the end of the lease you must relinquish this perfection of tillage, so as to be able to diminish your teams, or to employ them in other occupation which will yield greater profit. As far as possible, at this time, sow your seed after one or two plowings; and let your plowshares be very broad, so that you may be able to make furrows twelve inches wide. You need not trouble yourself about plowing the land to sow seed from which you will not gather the crop; it will be much more to your advantage to make merely a secondary operation of it.

6. It is a great advantage to be allowed to plow up old grass land and root up plantations. In seeking for a farm, you should always endeavor to obtain this privilege. But in such a case, from the very commencement, direct all the means and powers you have at command to the undertaking. The lands thus brought into a state of cultivation will produce at first fine crops of corn for market, and will afterwards, without manuring, continue to produce inferior kinds of grain until the end of your lease: it will matter little to you if they should then be completely exhausted.

7. Do not trouble yourself about the meadow land, excepting so far as is necessary in order to obtain fodder for your teams; for it does not repay the expense of management. If, towards the latter end of your lease, the meadows should have become marshy from want of drainage, or from the ditches being choked, or should be covered with thorns and bushes, or broken by mole-hills, and on account of these defects yield a small quantity of hay, and of an inferior quality, you need not concern yourself much about it—it will make little difference to you, as you would otherwise be prevented from disposing of your hay.

8. If you have taken the stock upon lease at a valuation, and have to return it in the same manner, remove all the best horses, oxen, and cows, and replace them by inferior animals, or otherwise pay the deficiency in money. In valuations of this description, good stock are always estimated at a proportionably lower rate than bad, and the latter look less miserable when the good are not placed by their side. Towards the end of the lease, do not put the bull to the cows, or, at least, do not let it be done until a very late period, in order that the cows may not have calved before the time of returning the stock; they will then appear to be in much better condition, even if they have been badly fed. The continuance of the profit of the cows which are not in calf, will fully compensate you for the loss of the surplus that those which recently calved would have afforded you. You should likewise include all the old harness and farming implements in the valuation, keeping all that which is no longer serviceable for this purpose, and having it repaired and put in order; as to the new, you may put it on one side. A miserable-looking stock often inspires those who value it with compassion for the farmer, and inclines them to treat him leniently.

9. It is, of course, understood, that you must not go to any expense in order to keep the gardens, ponds and buildings in order; the landlord generally takes upon himself all the larger repairs at the end of the lease; it is, therefore, your interest to allow the small dilapidations to become larger ones.

10. Exact all that the laws and customs will allow from those who owe you statute labor; it will not matter to you if they are ruined.

11. If the landlord should reserve any part of the produce for himself, and fix a high price on it, because it is the growth of his own land, and, consequently, offer you a considerable reduction of rent in return for it, agree to his proposal by all means. It is true that you will the sooner be at issue with him; but that would happen under all circumstances, especially if he resided upon the estate; and, besides, it can be of little importance to you if your lease is properly drawn up. If it should prove injurious to you at first, you have only to contrive to enlist on your side the servants who receive the produce for the landlord.

There are, undoubtedly, farmers, whose known character is a sufficient security to the landlord that they will not be guided by such maxims as those just quoted. There are some, too, who are such enthusiasts in agriculture that they will even sacrifice their own profits for the sake of attaining perfection. But men of this class are not very numerous; indeed, it is unreasonable to expect, even from an honest man, that he should, as a farmer, expend money upon an estate unless he has a very fair prospect of being able to recover it. That which does not improve, will certainly degenerate; it is, therefore, very seldom that a farmer does not leave an estate in a worse condition than when he took possession of it.*

The case is different with regard to lands which are government property; in some states these domains are farmed out for very short periods, but upon very liberal terms. According to the system pursued by these governments, the farmers are sure of a renewal of their leases, provided they act honestly and submit to the new valuations, which are always conducted on very equitable principles, and with a due regard to the improvements which the farmers have made upon the land. Sometimes, indeed, a more than ordinarily good management of their farm may justify the tenant in expecting to receive a better one, and to be able to leave it as an inheritance to his family. A man who holds his farm upon such terms may regard it almost as his own property, and act accordingly in all the departments of his management.

Under such conditions, the government lands have, no doubt, been saved from deterioration, although at the sacrifice of a considerable portion of their net produce.

In those states, on the contrary, in which the lands have been let to the highest bidder, without regard to his personal character, and a higher rent obtained in consequence, all the contracts, all the clauses introduced into leases, and all the restrictions to which the tenants have been subjected, have not been sufficient to preserve the land from serious deterioration, and, in spite of the continuance of the high price of corn, occasions a considerable diminution of rent as well as of produce.

* The editors feel that happily for the character of the great mass of the farmers of England, these remarks do not apply to them.

It is quite out of the question to expect that the farmer will undertake those more extensive improvements which tend to produce a permanent increase in the value of the land. Nevertheless, the opportunity of making them occurs so often, and the advantage attending them is so obvious, that both parties ought to be disposed to favor the adoption. It might be laid down as a rule that the landlord should furnish the necessary capital, which should be fixed at a certain sum; and that the farmer should pay him interest for it, at the rate of ten per cent., during the remainder of his lease. Under such an arrangement, the farmer would never propose any improvement, of the utility of which he was not well convinced; and the landlord would only have to consider whether the improvements were likely to be permanently beneficial to the estate.

With respect to repairs, it seems the most equitable manner would be for the landlord to furnish the materials, and the farmer the labor. The most absurd regulation which could well have been adopted, was that by which all the small repairs should be made at the expense of the farmer, and the large ones at the expense of the landlord.

*Hereditary Leases.**

An hereditary lease has the peculiarity, that it ensures to the tenant as much freedom in the use of the land as if it were his freehold property; and to the landlord, under certain proper conditions, a certain rent, independent of all risks, and subject to no diminution whatsoever.

The most important point, with regard to this system, is an accurate determination of the value of the land, or of its produce, after having deducted all the necessary expenses and a fair profit for the farmer. But as money has only a nominal value, and that value is constantly varying, it is most important that the value of the land, or its rent, should be determined not by money but by corn, the average value of which, with regard to other things, has for some time been fixed and will long continue in that value. It is true that this standard varies from year to year, and is for a short time even more variable than the value of money, but never for a long continuance; the value of grain preserves a constant ratio with that of all the real necessaries of life, because it is, in a great measure, the standard by which the price of labor is regulated.

For this reason the rent of hereditary farms, and of those which are held on long leases, should be calculated according to the quantity of corn usually grown in the country. It should not, however, be paid in kind, because then the rent would sometimes be very high and sometimes very low; but it should be paid in money, by the average rate of a number of previous years.

Moreover, a deduction should be made for those years in which the crop has failed, or in which, from this circumstance or others, the corn has risen to an unusually high price; because, in spite of the high price of corn in those years, the agriculturist must have incurred some loss, and the recurrence of similar circumstances is neither to be expected nor desired. Thus, it would be absolutely unjust to fix the average price according to those which have been obtained during the last ten years, in which the various crops have been below the usual average, or the prices have been still further increased by other accidental circumstances. By such a mode of reckoning it is more than probable, that in the course of a few years the farmers or tenants would soon be brought to ruin.

The following objection has been made to the system of valuing the rent of a farm according to the produce, that as the price of produce is liable to increase and diminution, it is impossible to be certain of a fixed rent. But this objection is altogether unfounded: the real value of corn remains the same—it is the nominal value only which is liable to variations and change.

The advantages of hereditary leases are manifold and striking; hence there is no doubt that at the present day, when more enlarged views are becoming prevalent, this system will soon be universally adopted, especially in those districts in which estates of considerable extent have been preserved; and also that other estates which have hitherto been farmed out for uncertain periods, and on conditions more or less burdensome to both landlord and tenant, will speedily be brought under the same system.

* A kind of *emphyteosis*. [*French Trans.*

Section II.

THE ECONOMY, ORGANIZATION AND DIRECTION OF AN AGRICULTURAL ENTERPRISE.

The word "economy" has latterly been used in various senses; the Germans give it a very indefinite signification.

Judging from its etymology and original signification, the Greeks seem to have understood by it the establishment and direction of the *ménage*, or domestic arrangements.

Xenophon, in his work on economy, treats of domestic management, the reciprocal duties of the members of a family and of those who compose the household; and only incidentally mentions Agriculture as having relation to domestic affairs. This word is never applied to Agriculture by Xenophon, nor, indeed, by any Greek author; they distinguish it by the terms, *georgic geoponic.*

The Romans give a very extensive and indefinite signification to the word "economy." They understand by it, the best method of attaining the aim and end of some particular thing; or the disposition, plan and division of some particular work. Thus, Cicero speaks of *œconomia causæ, œconomia orationis;* and by this he means the direction of a law process, the arrangement of a harangue. Several German authors use it in this sense when they speak of the *œkonomie eines schauspiels*, or *eines gedichtes*—the economy of a play or poem. Authors of other nations have adopted all the significations which the Romans have attached to this word, and understand by it the relation of the various parts of any particular thing to each other and to the whole—that which we are accustomed to term the *organization*. The word "economy" only acquires a real sense when applied to some particular subject: thus, we hear of "the economy of Nature," "the animal economy," and "the economy of the State," spoken of. It is also applied to some particular branch of science or industry; but, in the latter case, the nature of the economy ought to be pointed out, if it is not indicated by the nature of the subject.

In speaking of agricultural management, the French say, *l'economie rurale*, and the English, *rural economy;* and yet neither the one nor the other intend thereby to signify the absolute execution of agricultural operations, but only the division and circumstances or appurtenances of Agriculture. In Germany, where a Latin or Greek name has lately been thought to give dignity to a science, and has, consequently, been introduced into the title of most of the scientific works, some authors have begun to term, not only the science of Agriculture, but Agriculture itself, the *oekonomie;* and the word is used exclusively in this sense by many persons. It is for this reason that those who are supposed to practise the art with the greatest skill and science, are termed *oekonomen*, (economists;) and that some of those who are employed in superintending the laborers, even though they frequently have not the least idea of the actual principles of Agriculture, chose to be designated by this title.

But this word has likewise been employed in another sense, and one not less foreign to it. As it is evident that the principal object of skillful economy is to attain to some particular end at the least possible expense, they have given the term "economy" to frugality—taken, first, in its widest sense; and, secondly, in its more immediate application to money: and some have even gone so far as to comprehend avarice, although it should fail of attaining its end; and have called those who devote nothing to advance their Agriculture, but, on the contrary, exhaust and ruin it, *good economists.*

Attention to receipts and expenditure has also been termed "economy;" and those who had the management of religious societies were termed "economists." We shall adopt the Latin signification of the word, and, when using it with reference to Agriculture, simply imply that part of the science which teaches the most advantageous proportions, and that direction and application of the means which will be most likely to tend to facilitate and increase reproduction. This section, therefore, will treat of the establishment, the support, and the use of the powers by which labor is carried on; of cattle, or rather of the relation which exists between fodder, manure, and Agriculture in general; the necessary division of the fields, and the various systems of Agriculture considered as the means of approaching, in each locality, as nearly as possible to the aim of the undertaking—that of deriving from cultivation the highest and most permanent net produce; and, lastly, of the direction of the whole, and of its transcription into registers, diaries, and account-books.

LABOR IN GENERAL.

From labor Man derives or has derived all that he possesses. That which the soil produces without labor or cultivation is very trifling, and can only be taken into consideration in a wandering life.

We are indebted to labor for every kind of food, every comfort, and every luxury—for riches, and even for the capital necessary for carrying forward any branch of trade or science. It is the quantity and quality of the labor applied to any particular thing, which determines its value or natural price.

All labor requires, however, a matter or subject to which it is applicable.—The soil is the matter furnished by Nature for agricultural labor, and the products derived from it by this labor may be derived from all other matter by the application of the requisite industry.

It is not entirely and strictly right to suppose that all riches and the whole revenue of the nation arise solely from labor: the soil forms a considerable part of it. While, on the other hand, those who regard the earth as the sole source of every revenue, far exceed the actual fact.

A nation, inhabiting a very fertile country, will be able to raise itself to a state of ease, if not of luxury, much sooner than any other; but it too often happens that the fertility of the soil and the fineness of the climate render the people indolent, and indisposed to profit by these advantages.

Without cultivation, the soil will not produce anything; and it is that alone which gives to it the actual value. In the infancy of nations, each person took to himself as much ground as he chose to cultivate, without paying for it; because the country was not sufficiently populous to make this appropriation objectionable. But no sooner was the value which the soil may derive from cultivation perceived, than the chiefs and sovereigns took possession of the land and affixed a price to it. This price continued to be very low so long as there were not sufficient laborers, or science, properly to direct and carry on agricultural operations. But, as these two requisites increased, the price of land and also that of labor were likewise increased; and, consequently, the profits arising from both were augmented.

Thus, in well cultivated and thickly populated countries, there will always be found to exist a proportion or equilibrium between the prices of land, of labor, and of produce, which in ordinary years is seldom found to vary, and which, if deranged by any accidental circumstances, is very speedily rëestablished.

This proportion is not, however, the same in all places: it is regulated by the relation between the quantity and quality of the soil, and the powers which can be brought to bear upon it; or by the degree of science and skill employed, or the capital which is invested in the cultivation. Where laborers are scarce, and skill and capital at a low ebb, the value of land is diminished, while that of labor is proportionally increased. But, in a populous state, on the contrary, where labor is easily procured, science pretty far advanced, and where capital necessary for the prosecution of agricultural operations is large, the value of land is proportionally greater.

This proportion between the price of labor and that of land contributes greatly to form the various systems of Agriculture, which, in their extremes, may be

called *great* or *small cultivation* (*grandes ou petite culture*).* In those places where land is cheap and labor dear, it is always best to endeavor to obtain a certain quantity of produce for a considerable extent of surface, and with the least possible labor; but where, on the contrary, the land is very dear, and there are plenty of laborers to be obtained at a reasonable price, we must endeavor, by means of the greatest possible labor and care, to obtain an equal amount of produce from a small extent of surface, which is generally possible.

There are countries in America where an acre of land may be purchased at the price of a day's work. In Belgium, England, and some provinces of Italy, the same quantity of land can scarcely be rented at the price of eighty days' work per annum.

Whoever wishes to practice Agriculture, and has a certain capital, may, in the former case, purchase an extensive piece of land, although he may choose to cultivate only a portion of it; but he must adopt the great or general system of Agriculture, which will employ as few laborers as possible. But in the latter case he must content himself with a small farm, not only on account of the dearness of the land, but also because he ought to reserve a larger portion of his capital in order to meet the expenses of the additional labor which will then be necessary. Where the land is cheap, it is sometimes possible to purchase large estates, the statute labor due to which is alone sufficient for all the indispensable operations; and where, if a person has sufficient stock, a very small sum of money will suffice for the expenses of cultivation.

The lower the price of land, the less advisable is it to attempt improvements. Where an acre of land costs only fifteen rix-dollars, and the net produce of which is two dollars, it would, perhaps, be disadvantageous to spend fifteen rix-dollars on improving the soil, as by marl, for example, even if the produce would thus be doubled; because another acre of land might be purchased for that sum, from which the same amount of profit would be derived as would be produced by the improvements.

I say that it would, perhaps, be disadvantageous, because there are circumstances and cases in which it would be highly advantageous to devote that sum to the amendment of one acre of land, which would be sufficient to purchase a second.

For some time past agriculturists generally have complained of the excessive advance in the wages of servants and day laborers, and have regarded it as a crying evil. Many persons have attributed the high price of corn to that circumstance. In those countries in which statute labor has been suppressed, they have considered that alteration as the cause of the high rate of wages. But it is far more likely that it is the dearness of provisions, and the desire which is consequently felt to increase the amount of produce, which has raised the price of manual labor in proportion with that of money. The abolition of statute labor has rather tended to increase the industry of the laborer, and, consequently, the amount of work done has been much greater; and it ought to have the effect of lowering rather than of raising the price of labor.

But this complaint is often totally unfounded, and the advance in the price of labor is only imaginary. The value of money, with relation to other things, has diminished; while the price of provisions, and especially of corn, is much more advantageous than it used to be with regard to labor.

We will now proceed to point out those causes which are most influential in elevating or decreasing the price of labor, as calculated in money. They are as follows:—

1. *The price of provisions.* It is, of course, necessary that the laborers should earn enough to maintain themselves, their wives, and one or two children, and their support must be of a nature calculated to maintain their health and strength, and that of their children. If they previously possessed nothing beyond these absolute necessaries, and if provisions became dearer without the price of

* I must entreat my readers not to confound the expression small (*petite*) cultivation with that of bad (*mauvaise*) culture. The former signifies a detailed system of cultivation which generally increases the produce; and the latter negligence, or an unskilful method of proceeding. Neither is great (*grandes*) culture synonymous with good culture, but only with cultivation managed on an extensive scale, executed chiefly by means of teams, in which, from the extent of the whole, the farmer is frequently compelled to neglect the details for want of the means requisite to enable him to approach nearer to perfection by taking care of both the one and the other. [*French Trans.*

labor being also advanced, they would soon become so much enervated and impoverished as to be almost incapable of work; they could no longer maintain their children, or rear them up strong and healthy; and thus the quantity of laborers would, in a short time, be so much diminished, that the small number which did remain, capable of work, would be able to exact enormous wages.—This fact, alone, tends to prove the absolute necessity of the existence of a certain proportion between the price of provisions and that of labor; and this proportion can never be interrupted for any considerable time, or without great disadvantage; and it speedily recovers its own level.

If the price of labor should, from some particular cause, advance beyond its due proportion with that of produce in some districts, and the laborers are thus enabled to earn more than is required for the actual necessities of life, they marry much sooner, rear more children, and, the number of laborers becoming greater, wages fall again.

It is true that this result does not immediately take place; it is not regulated by all the variations in the price of corn, but simply by an average taken from a certain number of years. The effect of a sudden decrease in the price of provisions will be much sooner evident, because then the laborers, who have hitherto only known want, and who have not the slightest idea of frugality, will be able to earn sufficient for their maintenance in three days, whereas they previously had to work five days for it. In this case they are easily induced to work two days less in a week, and thus the amount of labor is considerably diminished, and those who have absolute need of it are obliged to pay for it pretty dearly.—But this state of things has also its limits, because, wherever this is the case, a great number of individuals will collect, and in the long run an increase of grain will only be found to stimulate a desire for still more.

In general, in all well-populated countries, the price of labor is regulated by that of provisions; and in the ordinary course of things, in most places and at most seasons, the same quantity of manual labor will be received for a measure of wheat, although the nominal price, that in money, may not be the same.*

In order to maintain a certain uniform standard of wages, an agriculturist who has established the necessary number of laboring families upon his estate, will act most beneficially to his own interests, and equitably towards them, by giving them a portion of their wages in provisions at a certain price; or, if he is certain of their work at all times, by increasing or augmenting their wages in proportion to the price at which these families can purchase these provisions.

In order to maintain himself, support his strength, and, at the same time, rear two children, a laborer ought to be able to earn a bushel of rye in eight days, without too great exertion or extra work: the wife is supposed to be capable of earning her own living. From time to time, and particularly when provisions are dear and the laborers have earned less, they have been indemnified by other advantages which rendered their existence possible, and which certainly ought to be taken into account when speaking of the price of labor.

I shall take one-eighth of a bushel of rye as the average daily wages of a man. And as the relative prices of labor and grain give, in agricultural accounts, a much more durable proportion, and is much better adapted to all times and all situations, than the variable value of money, I shall take this price of a day's work, or eighth part of a bushel of rye, as the ideal coin of our agricultural accounts, and shall designate it by this mark, ‡.†

If we wish to reduce this imaginary money to the current coin, it is only necessary to obtain the average price of a bushel of rye for ten years in the province or district which we inhabit. Thus, for example:—

If the bushel of rye is worth	1	rix-dollar, a	groschen	‡	will be equivalent to	3	gros	0	dem.
" " " "	1	"	3	"	‡	" "	3	"	4½	"
" " " "	1	"	1	"	‡	" "	4	"	6	"
" " " "	2	"	0	"	‡	" "	6	"	0	"

* The province of Vignolles is an exception to this rule: there each laborer receives a ration of wine every day; and as this draught but slightly diminishes the quantity of food, properly speaking, which he consumes, the price of his day's work is raised seven-eighths of the value of the wine; in fact, it is more than probable that this drink increases his strength. [*French Trans.*

† In those countries in which the peasantry are accustomed to enjoy more of the comforts of life, and where wheat forms a considerable part of their food, the eighth part of a bushel of that grain will be the equivalent of a day's work.—[*French Translator.*] One peck of wheat has been long reckoned a standard in England. [*English Translator.*

As the price of labor and the consumption form the most considerable part of the expenses of Agriculture, the abstract and hypothetical calculations which we shall have occasion to make with regard to the details of rural economy, will thus be rendered generally more admissible and more correct than if we were guided by money, which always indicates the mere nominal price of things, and not their actual value.

2. *The increase or diminution of the demand for laborers.* When the demand for laborers is increased, the latter naturally endeavor to get their wages raised, and thus the price of labor is advanced throughout the whole country.—An increase in the price of labor from this cause, so far from being prejudicial to the agriculturist, is, on the contrary, most advantageous to him. It is, at once, the effect and the cause of a diffusion of comfort and ease throughout the country: in the case of the agriculturist, it is, perhaps, connected with still greater advances; but it is certainly and invariably with additional advantages; for comfort, which is the fruit of industry, necessarily causes an increase of consumption, and with that a higher price of provisions. There is, however, an exception to this rule, viz., when the increased demand for laborers does not arise from any certain branch of industry, or of any permanent employment, but merely from some speculation or some temporary work, as the establishment of a new road, the cutting of canals, &c.; it is then that the sudden elevation of the price of labor becomes prejudicial, and is frequently very embarrassing to the farmer. If governments would avoid the derangement of the Agriculture of their country, they must never, in cases of this nature, levy all their laborers in the country itself.

If, on the contrary, industry has declined in some particular province, and labor is less sought for, then the laboring class of that place cannot obtain employment, and their salaries are, consequently, diminished. A diminution of the price of labor always announces the decline of industry; it is the forerunner of its total fall and of poverty, and, consequently, never can be advantageous to the agriculturist.

Nevertheless, as a demand for laborers in any particular district and an advance in their wages speedily brings a great number of them to that place, while, on the other hand, any great decrease of these two articles will drive them away or reduce them to poverty, it will generally be found that wherever laborers are required and well paid, they will congregate.

This price is, therefore, only temporarily modified during an increase or a decline of industry. If the price of labor has remained the same for some time, it is because there has been exactly the number of laborers that were required; for this price, particularly if we regard the real and not the nominal price of labor, and its proportion with the value of produce, is not usually higher in countries where the working classes find full employment, nor lower in those where the contrary is the case. Proper remuneration will always procure the necessary number of laborers in any country, whereas the want of it will cause them either to emigrate or to starve from want. Where the latter has happened, the farmer has frequently sought in vain for assistance in moments of emergency, and in seasons when he required it most; and as the laborers cannot get employment excepting at harvest or haymaking seasons, they take care then to make the farmers pay dearly for their services.

This is the reason that the price of agricultural labor is much lower in proportion to other things in England than it is with us; and that in some counties it is so inconsiderable, that the laboring classes could scarcely exist if they were not kept in constant work, and did not receive assistance from those charitable institutions which, on other accounts, are so burdensome.

In examining and calculating the price of work, we must be careful not to confound the price of the wages with that of the work itself. There are some countries in which the former is much higher than it is in others, while the latter is actually lower; for men differ greatly in the degree of their strength, activity, and skill, and much depends on their poverty or the comforts which they enjoy. A workman to whom I pay twelve groschen a day, can frequently execute more than double the work, both in quantity and quality, as another to whom I only pay six groschen. Consequently, where the laborers are industrious, and skilled in some portions of agricultural operations, it is cheaper to employ them, even though they may require somewhat higher wages.

Labor well applied is always productive of some profit, and those who spare it act on a false principle of economy; but the best and most judicious method of employing labor and time is the most important of all subjects to the real economist. Many persons learn this method from long experience; and it is true that the tact and *coup d'œil* thus acquired is peculiarly just. But it may be acquired much more promptly and definitely by the observation of certain principles, from which a theory of action may be deduced, without serving a tedious and expensive apprenticeship to experience.

It is far more difficult to apply labor judiciously to Agriculture, than to apply it to the manufacture of fabrics; for the labor which is required for some particular kind of produce, lasts but a very short time, and is then suspended for a much longer period, during which the farmer depends upon the action of Nature to bring this production to perfection, and awaits the proper season for gathering it. After each species of grain has been sown, it requires very little or no attention for some time; whereas, in the formation of any kind of fabric, the labor must be continued from the very commencement until the completion. In order, therefore, that the farmer may make the very best possible use of the powers which he has at his command, he should endeavor to arrange the succession of his crops in such a manner that every hour shall be devoted to some preparatory and necessary operation. It is also necessary that he should select the products so as never to have more necessary operations in hand at once than he can accomplish by means of the powers which he has at his disposal, or which are within his reach.

He must never undertake many extensive operations at once, or in places remote from each other. He should endeavor, as much as possible, to perform them one after another, and to employ upon them all the men he keeps, from the beginning to the end: this will render the task of inspection easier, and may also tend to excite that emulation which frequently arises when many laborers work together under the same superintendence. When only a few workmen are employed on some extensive operation, they frequently become dismayed at its length, and at the little progress they appear to make: they lose all spirit, and end by believing that it is impossible to discover whether or not they work at all. In great operations it is always better to have a man or a team too many, than to have one less than is necessary. In smaller operations, on the contrary, it is as well to avoid employing more laborers than are absolutely necessary; they only hinder one another, and are apt to think that the farmer believed that the work would take more time than actually is required for the accomplishment.

A judicious estimate of the labor requisite for every operation is, therefore, of the greatest importance; and it will easily be acquired by carefully observing the time and labor applied to each separate portion and to the whole.

There are some operations which require a certain degree of temperature: the farmer must always hold himself in readiness to set about those as soon as the fitting time arrives, and must get them done as soon as possible. Should he be interrupted by change of weather, it will be contrary to the rules laid down in the preceding section to pass to any other extensive operation, unless some particular motive, or an appearance of this change of temperature being of long duration, should seem to indicate such a course. In such intervals it is much better to set about some of the smaller operations, which are, in point of fact, of equally as much consequence, and can be very soon completed. It ought to be held as as a rule, that no operation once taken in hand should be laid aside, except in case of absolute necessity; and the farmer ought always to hold himself in readiness to resume that which was first undertaken as soon as the weather will admit.

In reaping or stacking corn, planting or digging potatoes, &c., on extensive farms, the division of labor may be so managed that one part of the laborers shall work with the teams while the others perform the manual labor; or that certain operations shall be committed to the care of certain men in each season. But the variety of these works seldom allows of the same individual being employed all the year round on one thing.

There are many operations which can be performed by women and children as well as by the strongest men, and the former cost much less. It is very important to distinguish those operations which ought to be executed by men from

those which may be accomplished by women or children, in order that each of these classes may be employed throughout the year on the work best adapted to their powers and strength.

On Draught Labor—Horses and Oxen.

As the number of laborers which it is necessary to employ depends greatly upon the teams which are kept, we shall commence by treating of these latter. Teams are, for the most part, composed either of horses or oxen. It is seldom that asses or mules are used.* There certainly are some countries in which the small farmers are in the habit of harnessing the cows,† and where such a proceeding does not seem out of place; I see no objection to these animals being taken into work in cases of need, but their general use does not appear perfectly right.

It has been a matter of dispute for some time whether the preference should be given to oxen or horses as beasts of draught, and both sides have contested the point with too much prejudice, and sometimes with too much animosity; this is one reason why the question has never yet been decided, and why no positive results have yet been arrived at on the subject.

The preference must certainly be given, in most situations, to horses, on the following considerations:‡

They are capable of all kinds of agricultural labor; they adapt themselves to every road and to every degree of temperature. Where horses are kept, there is

* The mule is peculiarly adapted to every species of agricultural labor. He lives much longer than the horse, he is much more abstemious, stronger, and capable of supporting the greatest fatigue. His only faults are, that he costs more; that his foot is straighter and narrower, and, consequently, sinks deeper into plowed land, and that he is apt to become vicious when ill-treated by the persons who have the care of him. Notwithstanding these inconveniences, the mule will always be found exceedingly useful in agricultural labor. [*French Trans.*

† Cows do not seem to be at all injured in health from being harnessed to the plow or wagon. When they are only worked half of each day, the value of their milk is not diminished more than + 0·13, and about twice as much if they are worked all day; but it becomes as abundant as soon as the animal is no longer required to labor.

No cow should ever be placed in the shafts, particularly in heavy work, which requires the simultaneous coöperation of more than one couple of draught cattle, or, indeed, in any work which requires extraordinary labor; because, although the cow may have sufficient strength to bear it, her efforts are very likely to produce abortion. Cows may always be used before oxen, provided that too great an exertion of strength is not exacted from them.

With a little exertion of patience and gentleness, a cow may usually be habituated to labor in a very short time; this will invariably be the case where the animal is broken in while young, and where they commence by making her draw light weights.

The pace of a cow is generally rather quicker than that of an ox; and when of the same breed, its strength and powers of endurance average about two-thirds of that of an ox.

Cows which are worked always require rather more food than those which remain in a state of inaction. According to the following proportion, the usual day's work of an ox is worth + 1·6; that of a cow, + 1·06. The latter costs the owner—

The additional quantity of food given during two days, supposing that the cow is only worked for half a day, each day 6 to 5 of the 100 kilogrammes	+	0·3
The loss in the milk	+	0·26
Accidents and misfortunes	+	0·1
		0·66
There is some deficiency in the quantity of dung; but in general that which is missed from the stable has fallen on some part of the fields, where it is not entirely lost, and the additional nourishment compensates for the deficiency in the stable.		
There is, consequently, a net profit on each day that a cow is worked, of	+	0·40

Or, to explain myself more clearly, the amount of work executed by a pair of oxen in one day will cost + 3·2, while that executed by two cows will only cost + 2.

And if, as will be seen by the note attached to p. 73, *post*, the expense of work executed by oxen is, when compared with that executed by horses, as + 4·32 is to + 3·1, so the quantity of work executed by a pair of horses in one day, and costing + 3·1, would, if performed by cows, only cost + 2·72.

Besides, the pace at which cows move being much quicker than that of oxen, if proper attention be paid to the manner of harnessing or yoking them, and to the equalizing of their strength by numbers, so that they may be able to overcome the same resistance as the latter, their conductor will find his time quite as usefully employed as if he were with horses, and much more so than if he drove a team of oxen.

But the benefits of which I have already spoken are not the only ones which are derived from the practice of harnessing cows; however judicious may have been the distribution of crops, it is almost impossible to avoid having an accumulation of team labor all necessary to be done at one particular period. By keeping the number of horses and oxen necessary to secure the execution of all these operations at the most advantageous and fitting time, the farmer will be burdened with a quantity of beasts which, during the greater part of the year, he will have no use for; and, consequently, each day's work will cost an enormous sum.—But by early accustoming his cows to labor, he will, on the contrary, always have a sufficient quantity of teams at his disposal, which are at no time in the year entirely valueless. [*French Trans.*

[This note of the French translator is inserted to show the opinions of a Frenchman on this subject.]

‡ The Royal Agricultural Society of England has deemed this question worthy of investigation.

no occasion to select the particular kind of labor to which they may be applied—they may be employed in any work, and be attached to every description of plow.

They perform all kinds of work very expeditiously, and are capable of sustaining their speed for a considerable length of time; consequently, the conductors are kept in fuller employment while working with horses, than when working with oxen.

Although less steady at heavy draught than oxen, the rapidity of their motion and their spirit enable them to overcome all obstacles of short duration which would frequently stop a team of oxen.

Oxen, on the contrary, have the following advantages in their favor:

They can execute most of the agricultural operations—plowing, draught, &c.—equally as well as the horse, and, when well fed, are capable of enduring almost as much fatigue. Many persons consider that they are more useful in plowing even than horses.

Their keep is much less expensive. The original price of an ox is generally far below that of a horse; their harness also is much less costly; their food is much cheaper, and is of that nature which finds a much easier sale than the corn which is given to horses.

Oxen, so far from diminishing in value when they are well fed and not overworked, frequently become more valuable, and, on being sold, often fetch more than their original price, thus almost paying the interest on their capital; whereas, the horses decline in value as they grow older, until they are worth little more than their skins, and the capital expended on them is thus completely absorbed.

Oxen are also less liable to accidents and disease.

Lastly, they produce a greater quantity of dung, and the manure derived from them is generally more useful than that which is obtained from horses.

We shall be able clearly to demonstrate that which must already be apparent, that even those portions of agricultural labor which can be properly executed by means of oxen will not be executed so cheaply by them as by horses. If all the operations on a farm were of such a nature as to be easily performed by oxen, these animals only ought to be made use of. Although the operation of harrowing is far better executed by means of horses than by oxen, yet this does not, in my opinion, form a sufficient consideration to induce the adoption of the former. But in most farms there are many operations which oxen are still less calculated for, or, at least, which they perform very slowly. This would be a sufficient motive to induce a determination to keep a certain number of horses, regulated, of course, by the amount and extent of these operations, and to limit the number of oxen accordingly.

It is seldom possible accurately to calculate the number of horses which will be requisite for those operations which cannot be performed at any season, and thus horses are frequently employed on operations which could be executed at a much cheaper rate by oxen. Nevertheless, it is of the greatest importance to determine, as far as possible, the proper proportions of each of those animals; but that proportion varies on different farms, and must be calculated according to the extent and management of each separately; consequently, only general rules can be laid down for the regulation of it. There are, doubtless, some farms which, from their vicinity to the market town, or some particular circumstances, ought to make use of horses only; because they contain so few operations which can be executed by oxen, that it will not be worth while to incur the expense of these animals, of a herdsman, &c.

In many countries, the chief objection to the use of oxen seems to be the difficulty and almost impossibility of finding laborers who will work well with them.

When the farmer wishes to make his oxen get through as much work as horses, and without employing more men, he must manage so as to have relays of teams; that is to say, one ox shall work only a part of the day, and shall then be relieved by another. This change may take place twice or thrice in the day. It is seldom, excepting when the oxen are very low in condition, that it will be necessary to make use of a triple number of beasts. In general, when they are changed three times in the day, the ox which was used first in the morning, and then relieved by another, may be re-harnessed in the afternoon: in this case he is only worked once on the following day.

A relay team of four oxen, employed on those operations for which these ani-

mals are best calculated, will do rather more work than two horses, if sufficient patience and perseverance is manifested by the conductor, who must not quit the spot during the whole time the labor lasts, and to whom the relays of oxen must be brought by the herdsman or cow-boy. It is, however, true that the same number of beasts, when they are not worked alternately, and only rest for a short time at noon, can get through more work than if they were used as relays; but then they must be better fed, and will, if worked all day for many successive days, become over-fatigued; but two oxen worked permanently will never be found to get through as much work as four worked in relays can do, and, consequently, their conductor is not so fully employed. The proportion between oxen worked as relays, and those which are permanently employed, is about three to four. This difference is, however, in part compensated by the increased labor of the man who conducts the team. But it must be confessed, that for every six oxen a supernumerary one ought to be kept. In those places where the farmers have learned to appreciate the advantages of relay teams, they do not appear at all disposed to discontinue them. Nevertheless, during the short days of winter, when it is only possible to work for a few hours each day, the relays may be separated, and allowed to work during the whole time.

It is a very common, but a very unfounded, prejudice to suppose that oxen must not be worked in the winter, or that they must be kept in idleness, and that it is not necessary to feed them well. In a well-arranged system of Agriculture, there is always work sufficient for the oxen in the winter, if the roads are passable.

The ox is not more sensible of the cold than the horse; on the contrary, if he is well kept during the winter, he is very lively and active. The danger of slipping down on the ice or frozen roads may be averted by putting on a light shoe. Those oxen which are well fed and moderately worked, are much more active and tractable than those which have been shut up all the winter in idleness.

Where oxen are used, more days are lost during wet weather, or when the roads are bad, than where horses are employed. If each horse may be reckoned to work three hundred days in the year—supposing, however, that, for every twelve horses, one is kept in reserve to supply the place of those which are sick—the number of days' work which must be reckoned for an ox is two hundred and fifty.

According to these data, and to the calculations which we are about to transcribe relative to the expense of keeping horses and oxen, it will be easy to decide in each particular case whether horses or oxen will prove most advantageous, and whether both or only one of these kinds of animals should be kept.*

With regard to cart and plow horses, we must observe that, in purchasing them, many farmers pay attention only to the lowness of their price, and never concern themselves at all about the time when the horses will no longer be ser-

* The question of whether the preference should be given to horses or oxen has been left, to a certain extent, undecided; and, indeed, in order to resolve it in such a manner as to remove all doubts on the subject, we must be possessed of a great number of experiments and observations, which would require considerable sacrifices, and, moreover, be exceedingly difficult to collect.

It is probable that the size and breed of the animal, the climate and nature of the soil, may affect the relative utility of the two kinds so much as to exert considerable influence on the expediency of employing them, and to render the one which is well adapted for one country to be exceedingly disadvantageous in another. We shall, however, endeavor to examine the subject with somewhat greater arithmetical accuracy than has hitherto been applied to it.

From experiments which I have myself made, and which, from their accuracy, are entitled to some degree of confidence, I am convinced that with beasts of draught, as well as with the human race, there are considerable differences between the quantity of food required by different individuals of the same species, and still greater differences in the quantity of food which they will actually consume if suffered to eat as much as they like. Thus, of a pair of horses of the same age and breed, one will often consume 22 kilogrammes of hay per diem, while the other will eat only 15 kilogrammes, or even less. I am also convinced that with the exception of a few individuals possessed with more sense, or more devoted to the interest of their master, than is generally the case, it is the constant practice of servants to give the cattle a greater quantity of food than they actually require.

Hence result the endless variations observable in the quantity of food consumed by cattle. According to my experience, a good draught horse of the usual size will eat from 16 to 22 kilogrammes of artificial hay, clover, sainfoin, or lucerne, besides corn—thus averaging about 19 kilogrammes a day.

If the horses are fed with natural hay, they consume about an eighth less; but, however excellent in quality this kind of food may be, the horses lose condition rapidly if corn be not also given to them.

This difference between natural and artificial hay is modified by the locality, the nature of the soil on which the grass is grown, the manner in which it is watered, and, lastly, by the plants of which it is composed.

An ox of the Swiss breed, of stature sufficient to make him equal in strength and vigor to a horse, without,

viceable. They always decrease in value, these persons will say, as they advance in age; and the higher the price we gave for them, the greater in proportion is our loss. By the purchase and sale of indifferent horses, it is scarcely possible to lose to the same amount; and the necessity of employing a large

however, being unwieldy, will consume from 17 to 23 kilogrammes of artificial hay per day, or 20 kilogrammes on an average. (A kilogram is equal to 2 lbs. 3 oz. 5 dr. avoirdupois.)

The harness of a horse usually costs about 72 fr.; the interest of which, at 5 per cent. amounts to...	3fr.	6
The annual wear and tear, including repairs, may be estimated at	12	0
The shoeing	14	0
Lighting the stable	4	0
Interest on capital, (suppose it to be 480fr.)	24	0
Decay, and chances of mortality	48	0
Cleaning and attendance in those days during which the horse does not work	5	0
	110fr.	6

I shall not here take into account the rent of the stables and hay-lofts, or the cost of the litter and of medicines; neither shall I make any deduction for the value of the dung. I suppose these items to compensate each other in the keep of both horses and oxen. In my establishment the oxen are far more frequently ill than the horses; and this is attributable to the following causes:—1st. They have suffered frequently from flatulency, through the ignorance of servants, who have fed them too plentifully on moist and very young clover. 2d. In very hot weather they have been often attacked with inflammatory diseases. 3d. Notwithstanding every possible care to prevent it, they have been wounded several times near the base of the horn in putting on the yoke. 4th They have often bruised their feet while drawing carts and wagons in dry weather, or over stony roads; and the same accident has sometimes happened when they have traveled some considerable distance over wet and heavy roads. This evil may, however, be averted by a light shoe.

The harness of an ox, comprising the half of the yoke for the head and neck, and the traces, usually costs about 12fr.; the interest of which, at 5 per cent. amounts to	0fr.	6
The annual wear and tear of this harness	3	0
The shoeing	3	0
Lighting the stable	1	0
Interest of the capital, (suppose it to be 288fr.)	14	4
Chances of mortality	7	2
Attendance during those days in which the horse does not work	2	5
	31fr.	7

An ox, when no longer used for work, may usually be sold at the price originally given for him, and will even fetch more than his original price if he has been put up to fatten; but this latter circumstance supposes that he has been kept in idleness for a considerable time, and has been particularly well fed and carefully tended, and is, therefore, altogether foreign to the present calculation. We will, therefore, suppose that the ox is sold at the same time of the year at which he was purchased, and in such a case he will fetch about the same sum. We will now sum up these data.

The keep of a good draught horse for 365 days, at 19 kilogrammes of artificial fodder per day, or its equivalent in clover, lucerne, green tares, or in boiled potatoes, or carrots, amounts to 6.935 kilogrammes, the value of which, at 5fr. for every 100 kilogrammes, is	346fr.	75
An additional supply of corn during two months of extra labor, before the horse is turned out to grass	8	0
Expenses already estimated	110	60
	465fr.	35

According to my own experience, I should say that a horse cannot be worked more than 260 days with advantage. The author, whose experience is of much longer standing than mine, gives it as his opinion that a horse may generally be worked 300 days in the year. If we divide the sum total by 300, we shall find that the daily expense averages about 1fr. 55c.

The feed of an ox amounts to about 20 kilogrammes of artificial fodder, or its equivalent in clover, lucerne, green tares, boiled potatoes, or carrots; total, 7,300 kilogrammes per year—the value of which, at 5fr. per 100 kilogrammes, amounts to	365fr.	0
Expenses above detailed	31	7
	396fr.	7

I should also estimate, from my own experience, the number of days which an ox can be worked in the year with advantage is 290; but our author reckons it at 250. Now, a day's labor of an ox being in value to that of a horse as 3 to 4, these 250 would only be equivalent to 187·5 days' labor of a horse. Dividing 396fr. 7c. by this number, we obtain a daily average of 2fr. 11c. In this calculation I have not taken into account the greater amount of time expended by the drivers of oxen in the execution of those operations which are performed so much more expeditiously by horses. Hence it follows that the same quantity of work which, when performed by horses, would cost only 3fr. 10c., would, when performed by oxen, cost 4fr. 22c. The calculations which are contained in some subsequent pages exhibit the numerous differences which exist in the manner of feeding animals in different countries and districts. That the prices of all commodities are equally variable, is a fact of which very few can be ignorant. I have not pretended to decide so delicate a question as the expediency of keeping most horses or most oxen, or of confining oneself either to horses or oxen; but have merely endeavored to put each of my readers in the way of making an estimation of their advantages or disadvantages for himself, according to the peculiar circumstances of his agricultural operations, and the price of each commodity in the country in which he lives.

There cannot be a doubt that, in places where the farmer has an abundance of pasture-ground at his disposal which he cannot otherwise employ, the saving it will produce to him in food for cattle during the summer will greatly modify this estimate; but this modification will not actually be so great as it appears at first sight, because the ox which has had to seek its food in the fields is neither so strong nor so fresh as one that has been fed in the stable and had a good supply of rich fodder.

It appears, also, that in some countries the ox is more moderate in his appetite, and consumes less food than those in the country in which I live; on this point every one must endeavor, by repeated experiments, to ascertain the average of his particular locality, and make his calculations accordingly. I have supposed the oxen to be fastened together with yokes; I am, however, far from admitting that this is the best method, but I believe it to be that which is most generally practised. [*French Trans.*

capital is also obviated, and less damage sustained in case of accident. They therefore generally purchase horses which have been badly used, or are no longer suited to the work for which they were originally intended, but which are, nevertheless, still capable of drawing the plow or the harrow; and they base this practice on recollections of animals thus purchased, which have been brought into such condition by dint of care and good feeding as to be equal to all the work required from them, and which have afterwards been sold for more money than they originally cost. If the maintenance of the horse, under different points of view, were the only thing which it was necessary to consider, this mode of proceeding would not be so bad. But, in agricultural operations of any extent or continuance, horses of this description are not to be depended upon.—They are subject to frequent attacks of illness, and the amount of work of which they are capable is very doubtful; besides, in cattle thus collected, all have not an equal proportion of strength, courage, or endurance; nor are they all equally accustomed to work; a regular and systematic course of tillage cannot be carried on with such teams, unless, indeed, several additional horses are kept in reserve. If we cannot depend upon the force which is at our disposal, all tables and calculations become utterly useless. It not unfrequently happens that a pair of horses, which are unable to work, and whose places cannot immediately be supplied at a time when several urgent operations are necessary to be done, will occasion a loss which will far outweigh the profit expected to result from the saving in question. The non-employment of the one, causes irregularity in the work of several others. I am, therefore, of opinion that these worn-out horses can only be advantageously purchased for spare or relay teams, or to be temporarily employed in improvements, buildings, or repairs.

The principal teams should consist of horses of the same breed, well set about the shoulders and neck, having a deep chest, and round in the carcass. They should not be large boned, but have plenty of sinew; should be docile and patient, not too spirited, and have good legs and feet. It is only on very tenacious soils that it is necessary to use the large heavy horses, which require an abundant supply of food and very great care in order to keep up their strength. For plowing, it is necessary to have robust horses, which are able to stand constant work, and keep up their flesh and strength even when badly tended and irregularly fed.

This breed of horses was formerly common to several provinces of Germany; but, at the present day, it is becoming scarce, because the growth of those belonging to small farmers has been retarded or impeded by want of attention, and by premature labor; and on the large estates the breed has been crossed and recrossed, until it is deprived of all those qualities which rendered it so valuable for agricultural purposes.* Those among the large farmers who do not breed horses, and endeavor to improve and beautify the race to the utmost, expressly for the purpose of selling them to the highest bidder, have almost wholly abandoned the practice, from the persuasion that they can purchase all those which they require for their agricultural operations at a much cheaper rate than they could rear them on their own estates.

But those who know the value of a strong, active, vigorous, and well-proportioned breed of horses, will consider the advantage of possessing such animals as are fully equivalent to the extra expense of rearing them. A team of horses, bred upon the land, and matched not so much with regard to color as to bodily strength and endurance, may be used with a degree of confidence which can never be felt when using cattle differing from each other in qualities and in breed, or which were purchased at different places. Low-priced horses, and especially those which have already been in the hands of horse-dealers, have generally been forced in their growth, and subsequently brought into condition by rich and plentiful feeding; and have thus laid the foundation of a variety of diseases. This internal weakness in horses is the cause of frequent accidents, and it is often difficult to discover whether they are attributable chiefly to want of attention or to weakness of constitution. When horses of different breeds are harnessed together in the same team, and it is difficult to avoid this where the horses are sepa-

* An evil which exists to an incalculable extent in this country. A colt or a calf is what is sought for, no matter what the character; the principal question is, at how small a price the services of the male can be procured.

rately purchased, they harass and impede each other; the quick ones incommode those whose movements are slower, and these latter are a hindrance and a drag upon the quicker.*

Moreover, in the generality of agricultural establishments, as we shall elsewhere prove, the rearing of horses is neither so difficult nor so expensive a matter as is generally imagined.

When the mares are put to the male at the proper season, little of their work is lost. The time at which they bear a foal and begin to suckle occurs at a season of the year when they may be allowed to rest, and from that time they require no further attendance.

In external appearance a good ox should be distinguished, not so much by hight and length as by a square built form, his neck should be finely shaped towards the head, and thicker towards the shoulder and breast; the chest should be deep and broad, the flanks full, the loins wide, and the hips large. The back should be straight and broad, and nearly level from the head to the rump. The legs straight and sinewy, and hoofs long and hollow; and both legs and feet should be supple, and not stiff and awkward. The ox ought not to knock his hinds legs together, as is often the case with those which are narrow and high in the legs. He should have a brisk air, and a backward glance of the eye, without, however, being shy or intractable. Large and smooth horns are at once an indication of health and strength, and useful for fixing and supporting the yoke and the guides. The English consider a thick, clumsy head, and a large dewlap, as an indication of weakness or deficiency in other parts; while many persons, on the contrary, regard these as favorable signs. The hight of the ox from the feet to the withers, to which many give exclusive attention, is a very uncertain indication.

Young oxen may be harnessed at the age of five years; but if the farmer wishes his cattle to acquire their full strength, and to retain it for any considerable period, he must avoid over-loading or over-working them before they have attained their seventh year.

It is the opinion of most agriculturists that an ox should not be suffered to live more than ten years, because, after that time, he becomes unfit for fattening, and it is difficult to dispose of him. Nevertheless, even supposing that an ox does lose somewhat of his disposition to fatten, and his flesh becomes less valuable—facts which I have never yet been able to discover, since I have often obtained excellent meat from oxen thirteen years old, which have fattened kindly—the work which strong and well-trained beasts of this description are capable of performing, will alone render it worth while to keep them longer. It is not until his ninth year that an ox acquires his full strength and vigor, and is best able to endure fatigue; and he will continue equally active until he is sixteen years old, if he has not been over-wrought in his youth.†

Few things require so much care, patience, and attention as the training of oxen, accustoming them by degrees to draught, gradually increasing their load, and teaching them to move more quickly by harnessing them with those which move rapidly. Their subsequent utility depends, in a great measure, upon this training; and it is, therefore, most important that the business should be entrusted to experienced persons, who will prevent them from acquiring a habit of creeping along, without the general cause arising from over-loading or over-heating them.

If, in rearing, tending and training oxen, the same care and attention were used as are bestowed on horses, the improvement of the ox might be carried to a very great extent.

* The author very judiciously recommends the having a select breed of horses on every farm, suitable to it, and, when once obtained, to breed from that stock, in preference to buying animals from totally unknown sources, provided circumstances will permit. By breeding horses, better opportunities are afforded of procuring constitution, strength and action in the animal, and the necessary equality in these particulars; and also a proper training, by which many vicious habits are prevented.

† The age of oxen here mentioned appears extraordinary, being so much greater than is known to attain in England. The early maturity to which our breeds have been forced, may, in some measure, account for it; but an ox capable of work at the age of sixteen years, seems to require a greater cause to occasion the difference. Ours are rarely worked beyond seven years old. There was, some years since, a wild ox at Chillingham Castle, in Northumberland, which had reached the age of seventeen years, having been kept for the purpose of trying the period of extreme longevity. The animal died at that age, having for some years previous been unable to move to any distance, or to feed on the usual articles of maintenance. The ages stated by the author appear incredible in our country. [*Editors.*

In the feeding of horses the following instructions must be attended to. The kind of grain generally given to them is oats, and many persons consider this as the only kind of grain which is good for them. It is, however, certain, that a proper quantity of any species of grain, each in proportion to its nutritive qualities, is both profitable and beneficial to horses.

Vegetables, as beans, peas, and tares, are perfectly well adapted to the constitution of the horse, and are even preferable to grain properly so called. The kind of grain which can be given to horses with most advantage, is always that which can be obtained at the cheapest rate in proportion to its nutritive qualities. The proportional value of different kinds of grain, as will be shown more at length in another place, is as follows:—

Oats	5	Wheat	12
Barley	7	Vegetables	10 to 11
Rye	9		

It is customary to give the horses a quantity of hay along with their corn, the nutritive qualities of which cannot be denied; and also chopped straw, which latter is given with the intention of facilitating mastication and filling the stomach, but which contributes little towards nutrition, properly so called, when there is no grass mixed with it.

In proportion as the quantity of hay is increased, the quantity of corn may be diminished, and *vice versa.* Experience tends to prove that an increase of corn is most advantageous for quick and forced work, but that an additional quantity of hay is best for slow and continuous labor.

A tolerable-sized horse, properly worked, generally requires about 10 pounds, or 3 *metzen* of good oats a day throughout the year, and as it is frequently necessary to increase this quantity, the yearly amount must be reckoned at 70 bushels.*

Besides this allowance of grain, it is also necessary, in order to keep up the strength during long and continuous labor, to give 10 pounds of hay each day; and, lastly, a quantity of cut straw is mixed with the corn, and increased or diminished in proportion with the quantity of hay given to the horse.

The annual feed of a horse, therefore, costs—

70 bushels of oats at 5 ‡	350	
33 quintals of hay at 3 ‡	99	
		449

To which must be added—

Interest of purchase money	24	
Annual decay	48	
Shoeing	14	
		86
Total		535 ‡

The straw is omitted, as being compensated by the value of the dung.

If a bushel of rye be valued at 1¼ rix-dollars, one ‡ will be worth four groschen six deniers, and consequently a horse will cost one hundred rix-dollars and seven groschen per annum.

It is very difficult to estimate the yearly expense of the keep of a horse in those places where they are grazed all the summer, or where they are fed during winter on chaff only, or during harvest time on the cuttings of the sheaves and a little corn; these customs are altogether incompatible with an active system of cultivation, and are not at all calculated for those teams which are in constant work.

There is now no longer any doubt that horses may be kept in perfect health and vigor without having any corn, and by means of a far less expensive system to the farmer, viz: that of giving them clover and green tares in summer, and potatoes, carrots, and other nourishing roots, in the winter. Although the quantity of these roots consumed by the cattle is so great as, when the value of them is reckoned according to the market price in towns, to render the advantage derived from the use of them apparently doubtful, yet, since they are less expensive to the grower than corn, and the carrying of them to market would be

* The word here and elsewhere translated bushel is a German word (scheffel). It seems to be applied to a great many different measures. At Berlin, the *scheffel* is nearly twice as much as the English bushel; at Stutgard, between three and four times as large as at Berlin; at Weimar, between two and three, and at Munich, four times as large. The *metzen*, also a German measure, seems to be of such a size that 14 two-fifths are required to make a bushel.

attended by very great inconvenience and expense, it is better to have them consumed by the cattle during the progress of the agricultural operations. The results of several experiments performed on a large scale have rendered the advantage of this system of feeding no longer doubtful, and when it has become generally understood and adopted, the question as to the respective merits of horses and oxen will, perhaps, be differently considered. We shall enlarge more fully on this subject elsewhere.

In order to keep oxen in good condition, they should receive, on an average, 20 lbs. of hay each per day during the whole of the time that they are kept upon dry food; consequently, 40 quintals of hay must be allowed for each ox. If a considerable quantity of chaff or winnowed siftings be given, 30 quintals will be sufficient. By this means their strength and health will be fully sustained, and they will be equal to all the labor which may be required of them during the winter.

In those establishments where so great a quantity of hay cannot be spared for the oxen, its place is supplied by the grain which is best adapted for this purpose, after having passed under the mill-stone (crushed). A bushel of oats* in the feeding of cattle is equivalent to a quintal of good hay. If, therefore, an ox receives 3 lbs. of oats per day, his daily allowance of hay may be diminished by 6 lbs. and his strength will not decrease in consequence, and may possibly augment.

The best food for oxen during the winter season certainly is potatoes and other nourishing vegetables. If an ox receives two metzen† of potatoes, together with 12 lbs. of hay per day, numerous experiments tend to prove that he will be kept in full vigor.

In summer, when the oxen are turned into the pasture-field, one and a-half cows are usually reckoned to each ox; consequently, if the cost of a cow be estimated at four bushels of rye, or 36 ‡, that of an ox at pasture must be estimated at 54 ‡; or they are fed in the stable on green clover, tares, or other esculent vegetables. An ox, when rather severely worked, will consume one and a-half square perches of red clover on an average per day, in two feeds, and, consequently, an acre and a quarter in about four months. If an acre of clover be valued at 36 ‡, this will amount to 45 ‡.

Thus, the maintenance of an ox, according to the different methods of which we have spoken, may be estimated as follows:—

(*a*)	40 quintals of hay, at 3 ‡	120
	Pasturage in summer,	54
		174 ‡
(*b*)	Hay for 200 days, at 18 lbs. per day, 3,600 lbs. at 3 ‡ per 110 lbs.	98
	Oats for 200 days, at 3 lbs. per day, 12½ bushels at 5 ‡ per bushel,	62½
	Pasturage,	54
		214½ ‡
(*c*)	Hay for 200 days, at 10 lbs. per day, 2,000 lbs.	54
	Potatoes for 200 days, at 22 lbs. per day, 44 bushels at 1 ‡ per bushel,	44
	Pasturage,	54
		152 ‡
(*d*)	Stable Feeding:	
	18 quintals of hay at 3 ‡ per quintal,	54
	2 metzen of potatoes per day, 21 bushels at 1 ‡ per bushel,	21
	Green clover,	45
		120 ‡

In point of intrinsic value or nutritive quality, it may be admitted that 110 lbs. of hay are equivalent to 48 lbs. or one bushel of oats, and to 200 lbs. or two bushels of potatoes. But the cost of reproduction, which the agriculturist should take as the basis of his calculation in all his own operations, is sometimes, as we have already observed, very different, and the market price is also subject to very great variation. Sometimes a bushel of oats will sell for more and sometimes for less than 110 lbs. of hay; and even when they are equal in value, it

* About 26 kilogrammes.

† About 6 kilogrammes, besides straw *ad libitum*.—FRENCH TRANS.

will be more advantageous to the farmer to give his beasts hay than to give them oats, because the former will yield a greater quantity of dung. It is the existence of this difference between the intrinsic value, the cost of reproduction, and the market price, which gives rise to the advantage of feeding cattle in one way rather than in another, and in part, also, to the advantage of keeping one species of cattle in preference to another, according as the kind of food the consumption of which is most profitable is best adapted to one or the other of these species.

Whichever of these systems of feeding may be adopted, the oxen, so far from losing condition or decreasing in strength, will, on the contrary, increase in value so much as even to cover the interest of their capital. If, however, in consideration of this interest and of casualties, 12 ‡ be added to the sum total, the keep of an ox in the best possible manner will even then scarcely amount to one-fourth of that of a horse; and even if we admit that four oxen working in relays will not do more work than two horses, it will still be done cheaper than if it were performed by these latter animals. It must, however, be observed, that in bad weather oxen working alternately are not available for so many days as horses, and that the proportion of the one to the other is 2 : 3, or at most 5 : 6.

In treating of the working of teams, we must also consider the implements by means of which the operations are performed. It is of greater importance than most persons seem to imagine, both as regards the execution of the work and the saving and the better employment of power, that the construction of the implement should be, as far as possible, perfect, and adapted to the locality, the soil, and the end which is to be attained by the use of it.

Although so much attention and study have been devoted to the improvement and perfecting of machines for the manufacture of fabrics, and so great and surprising a diminution of labor has resulted from it, yet little attention has hitherto been paid to the improvement of agricultural implements. This appears to arise, in a great measure, from the indolence of the farmers, from their want of mechanical skill, and perhaps, likewise, from the declamations of certain agricultural theorists. These persons have, in fact, inculcated the closest economy in the use of agricultural implements, and advised that they should not only be constructed at the least possible expense, but also that their number should be limited as much as bare necessity will allow.

They argue thus: the keeping in order of a plow of the least expensive kind, annually amounts to five bushels of rye, equal to 45 ‡. Now, if I can carry on my agricultural operations with ten plows of the same kind, and, nevertheless, ought to have plows of two or three different kinds, I must have at least a twentieth, and, instead of 50 bushels, these plows will cost me 100 bushels per annum, an expense which will scarcely be compensated by a saving in the employment of animal power. But even setting aside the better quality of the work, it will easily be perceived that this calculation is founded on erroneous principles. There certainly is less wear and tear in implements that are worked alternately, than in those which are in constant use; and if, when not wanted, they are carefully put away in a dry place, the wood, by being dried from time to time, will be kept in better preservation than if constantly used on a humid soil; this is so much the case, that it would even be advisable to have spare plows if only one kind were requisite. Nothing, then, but the interest of a larger capital can be charged to the account of this diversity of implements. Consequently, if an establishment which requires ten plows should absolutely spend 300 bushels of rye in procuring implements of a superior quality, or different construction, no annual increase of expenditure could thence arise beyond the interest of these 300 bushels; that is to say, fifteen bushels, and this would soon be compensated by the mere saving of animal power.

The enumeration, valuation and description of agricultural implements must, however, be deferred to another chapter. At present we shall content ourselves with observing, in order accurately to determine the relative prices of these labors, that in general the expense of the whole gear in which, and with which, a horse works, may be estimated at the value of ten bushels of rye per annum. It will, of course, be understood that this estimate will be subject to modifications arising from locality, the price of blacksmith's work, the charges of the cartwright, the harness-maker, and of the rope-maker; and the nature of the soil and the condition of the roads. The cost of the gear of an ox, when employed

only at the plow, has been estimated at no more than one-fifth of this sum. If they are also employed in carts and wagons, a kind of work for which they are not so well adapted as horses, but in which they cost less and do not require such expensive harness, the cost of two oxen working alternately must be estimated at scarcely half that of one horse. The harness-maker has little or nothing to do with the harness of oxen.

In order to obtain all the necessary data for a general valuation of the expenses of teams, we shall speak likewise of the men who work with them. It is principally necessary to know the exact power of the team to which the man is to be appointed.

If the expenses arising from the employment of carters were not taken into account, it would be most advantageous, according to the laws of mechanics and the results of certain decisive experiments, to employ beasts of draught singly as much as possible. For it is an acknowledged fact, that when the carriages are light in proportion, the animals can draw a much heavier load, and continue at work for a much longer period when harnessed separately. Four horses harnessed into two carts will draw a much greater load than when all are attached to a single vehicle. But they never draw so much as when each one is harnessed separately in a two-wheeled cart of suitable construction. Experiments made in England have proved that four horses harnessed separately in four two-wheeled carts are equivalent in power to eight harnessed together in one wagon. This is accounted for by the deviation of the different lines of traction, the unequal application of power, the want of absolute conformity of motion, pace, and traction, and the frequent action of forces in opposition to each other, which takes place when the horses are united in one team. When a horse works alone he may keep the true line of traction, and preserve an uniform rate of motion; he is not urged on by emulation, or forced into exertions beyond his strength by the activity, or impeded by the sluggishness, of his companions. But the horses must be well trained and be accustomed to the guidance of signs and words, and the harness and vehicles must be carefully arranged, or it is utterly impossible that one man can regulate and guide three or four horses, when each one is attached to a separate cart. And .since it is impossible always to employ an equal number of one-horse vehicles at a time, only one man is kept for the horses, who takes care of them in the stable, and those which work with them are hired by the day or by the task. This system also requires good and even roads.

If, according to our custom, the servants who look after the horses are also made to work with the teams, only one man is usually allowed for every four horses, and, in that case, when the work is heaviest the straw is cut ready for him. In some agricultural establishments two men are allowed to every four horses, the second being termed assistant carter or stable-boy. This arrangement is generally found on, and is particularly adapted to, those farms in which the horses are principally used for plowing, and are harnessed in pairs instead of teams consisting of four animals.

Where four horses are worked together, it is customary at times, when it becomes absolutely necessary to separate them, to entrust two to a day laborer, or an assistant driver is kept for a number of teams.

The custom of using three horse teams, which has lately been introduced into some countries, or that of keeping one man for three horses, is in my opinion disadvantageous. If the expenses of the household, properly so called, be equally divided amongst the several persons which compose it, the keep of the man who looks after the horses must be regarded as equal to 34 bushels of rye. I estimate the wages and other perquisites of each servant at 16 bushels of this grain. According to this calculation, a man capable of driving and taking care of a team of four horses, will cost the value of 50 bushels of rye per annum.

With regard to oxen, it is generally managed that one man shall attend to and feed or look after them in summer while they are grazing; but those who work with the teams and who remain all day in the field with the relay teams are, for the most part, day laborers; and at each change the relays are brought to them by the herdsman. The expense of this man may be estimated at the value of 40 bushels of rye per annum. He can very well look after thirty oxen, and such a man must be kept even for a smaller number of beasts.

I am well aware that in many countries the maintenance of a servant is valued

at a much less sum; but in the greater number of cases it will be found to amount to that now stated.

I shall now recapitulate the expenses of labor as performed by horses and oxen, and draw a comparison between them.

The expense of a horse is as follows:—

Feed,	449 ‡
Interest of capital, depreciation in value, and shoeing,	86
The harness and implements with which he works,	90
A man to take care of four horses cost 400 ‡, consequently one-fourth, or 100 ‡, must be reckoned to each horse	100
	725 ‡

If, then, 300 days' labor cost 725 ‡, each horse will cost 2·41 ‡ per diem. But if, during one-half of this time the horses work separately in two teams, so that the four require an extra day-laborer for 150 days, we must add 37·5 ‡ per annum to the cost of each horse, and consequently the value of a day's work will then amount to 2·54 ‡.

According to the four methods of feeding oxen, the expenses of which have already been calculated, an ox, if thoroughly well fed, will cost:—

For feeding	168½ ‡
Risk	12
Harness for team	22½
Herdsman (reckoning this man at 40 bushels for 30 oxen)	12
Extra driver for 150 days	62½
	272½ ‡

Two oxen working alternately therefore cost 555 ‡.

Thus, during the 250 working days, which is usually the average number in a year, the labor of two oxen working alternately will cost 2·2 ‡ per day. The labor of a horse costs 2·54 ‡ per day; that is to say, 0·34 ‡ more than two oxen working alternately. Local circumstance may easily modify this difference, rendering it sometimes greater and at other times less. It should be particularly observed, that we have here founded our calculations on the supposition that the oxen are better fed than they are in general, and we have also supposed them to do much more work than is usually exacted from them in our country.

In all those agricultural operations for which oxen are as well adapted as horses, two of the former working alternately will do more work than one horse; but there are many circumstances in Agriculture in which the superiority of oxen is far less considerable; sometimes, in fact, it diminishes so much as no longer to compensate for the trouble of attending to two kinds of draught cattle, or for the inconveniences attending the use of two kinds of teams. For instance, on a farm which would require at least twelve horses, and where eight oxen might also be employed, it would be much better to keep four additional horses instead of the oxen; unless, indeed, the pasturage for the latter, and the care which they would require, should amount to very little.

The following are the principal kinds of labor performed with teams:—

1. *Plowing.*—The data concerning the daily amount of work executed by a plow vary considerably. Some persons, from their own experience, state it to be 1¼ acres; others, 2½; and some even 3 acres. All these data are founded on actual observations; but we must weigh and examine all the circumstances under which the observations were made, and which occasion this difference. The principal reason is the breadth of the furrow. If a plow cut furrows 6 inches wide on a surface of 30 Rhine-perches in extent, I shall have to make 720; but if, on the contrary, I make these furrows 10 inches wide, I shall only have 432. Supposing this surface to be 30 perches in length, the team will, in the former case, have to travel over 10 4-5 geographical miles, and in the latter 6 12-25 miles, not reckoning the distance passed over in returning to the ends of the furrows. It should, therefore, always be borne in mind that the quantity of work which can be executed by one plow in a day is regulated by the width of the furrows or trenches.*

On land of a medium quality, the furrows are usually made 9 inches wide.—In this case the plow passes over a surface of 14,400 perches, or 7½ geographical miles, in the space of 5 acres. The turns will be more or less frequent, and, consequently, the distance passed over in turning greater or less, according to the

* A Prussian acre contains only 3,053 square yards—a statute acre, 4,840.

length or breadth of the land which is to be plowed; and 7½ miles may, however, be taken as the average in most cases. If, in consequence of this breadth of furrow, 2½ acres are plowed in a day, the beasts of draught and the men travel over 3¾ miles, and this is the utmost that can be expected from them in continuous labor. The narrower the trenches or furrows, the smaller the extent of ground which can be plowed in a day, and *vice versa*. It is likewise necessary to consider the nature of the soil, whether it is light or tenacious. The next thing to be considered is the depth of the furrow, in which every additional half inch, especially where the soil is heavy, often makes a very great difference in the resistance which it opposes to the plow.*

Lastly, the construction of the implement is of considerable importance. A well-constructed plow overcomes the resistance of the soil much more easily than one of inferior construction; this may be particularly observed in argillaceous soils, and where deep furrows are cut; the cattle are less fatigued by a good plow, and they can move more rapidly and their progress is less impeded.

On light soils, where the friction is not very great, the ground is usually prepared by a horse-hoe; this method facilitates the cutting of deeper furrows in plowing.

After what has just been said, it will no longer be a matter of surprise to find such discrepancies in the reports furnished by practical agriculturists of the quantity of work performed by their plows. But it is, generally speaking, very necessary to make a distinction between the performance of the plows when particular attention is paid to them, at the times of press of work, and when the weather is favorable, and their average performance throughout the year.

This kind of labor and the moving power which it requires, will be enlarged upon when we treat of plowing in particular. We will here admit that in the latter part of the autumn, on what is called barley land, composed of equal parts of argillaceous and sandy soil, two acres per day may be well plowed; and when the furrows are deeply cut to extirpate the harvest roots, an acre and three quarters per day may be plowed. In the spring two acres may be plowed for peas, oats, and the first barley-crops; and two acres and a half for the second. In breaking up the land to lie fallow, two acres; in plowing the ground over again, two acres and a half; and in plowing for seed, two acres and a quarter. These are averages which may be exceeded when the weather is favorable, or diminished when it is not propitious.

In general, a plow drawn by two good oxen, working alternately, will execute a quarter of an acre per day more than one drawn by horses.

2. *Harrowing.*—In this operation there are still greater differences in the amount of work done than in plowing. In fact, every thing depends on the care and on the implements with which this important process is executed. Cross-harrowing is most efficacious, and also most difficult; and it is generally considered that sixteen acres is the utmost extent of surface which can be harrowed by a team of four horses in a day. Fourteen acres of tenacious lands infested with weeds, is a good day's work; but if it is only requisite to equalize, and not to break the clods, such a team can harrow twenty acres per day. If the operation is performed lengthwise—that is once up and once down—it is possible to harrow from twenty-four to twenty-eight acres per day with a team of four horses.

* PLOWING TABLE, BY MR. JOHN MORTON.

(*Farmers' Almanac, by Johnson and Shaw, Vol.* 1, *p.* 191.)

Breadth of Furrow Slice, or Scarifier.	Space traveled in plowing an acre.	Extent plowed or scarified per day, at rate of	
		18 Miles.	16 Miles.
Inches.	Miles.	Acres.	
7	14 1-8	1 1-4	1 1-8
8	12 1-4	1 1-2	1 1-4
9	11	1 3-5	1 1-2
10	9 9-10	1 4-5	1 3-5
11	9	2	1 3-4
12	8 1-4	2 1-5	1 9-10
13	7 1-2	2 1-3	2 1-10
14	7	2 1-2	2 1-4
15	6 1-2	2 3-4	2 2-5
16	6 1-6	2 9-10	2 3-5

Horses are generally employed in harrowing, on account of the greater rapidity of their action ; but oxen may also be used with nearly as much advantage.

3. *Rolling.*—This operation is generally omitted in the list of operations ; it is, nevertheless, a very useful one, and adapted both to light and heavy soils. In proportion as the roll is broader and thinner, or shorter and of larger dimensions, the greater or less will be the labor of the cattle in drawing it. Where the cylinder is eight feet long, it will be easy to roll eighteen acres per day.

Angular and pointed rollers, called spike-rollers or clod-crushers in England, are much heavier, and require more power to move them. Having spoken of those operations which are requisite in order to prepare the ground for sowing or planting, we will now proceed to notice those which take place during the growth.

To the former belong the tillage performed by the large double extirpator with eleven shares, by the use of which four horses and two men can finish eighteen acres per day ; and that performed with the small extirpator, or sowing plough, with which one man and two horses can get over ten acres per day.

The trenching plow is also intended for operations of this kind, as by means of the mould-board attached to the coulter, it divides the trench horizontally into two parts, and throws the upper one to the bottom of the furrow. This implement requires an additional horse or ox in order to enable it to execute as much work as another plow. Two horses or oxen can draw it, provided that less work be required of them ; and this latter method accords best with the habits of the animals. The implement is chiefly used for breaking up grass and clover lands.

To the second class of operations belongs the tillage performed with the horse-hoe and the various kinds of rakes, "passauf," and cultivators drawn by horses, and by means of which one or two men, as may be most convenient, with one horse, can till six acres of land passing between rows two feet apart. Those plows which are intended for cutting deeper furrows in draining, have two mould-boards, which may be more or less separated at the hinder part, and these implements require two horses.*

The drill-plow for sowing seed in rows eight or nine inches apart, will, when worked by two men and a horse, sow twelve acres a day ; we shall, however, suppose the average to be ten, on account of the delays which sometimes arise.† The hoe with six shares, which is united with this implement, will get over from twelve to fifteen acres per day when drawn by one horse and guided by two men, according to the nature and condition of the soil, and the skill and practice of the laborers.

4. *The carrying of manure.* This operation, which in a well-conducted establishment is by no means inconsiderable, cannot be estimated with any degree of precision, except on a given locality ; since it depends, in a great measure, on the distance of the fields, the state of the roads, the season of the year, and on the weather.

5. *Carrying the Crops.* This operation also varies according to distance.—Where relay wagons are kept, a team of four oxen will be sufficient for seven, eight, ten, twelve, and even sixteen wagons. A wagon load of corn is generally regulated by fifteens, scores, or fifties of sheaves ; but as these latter vary in size in different places, in some districts weighing only eight pounds, and in others nearly fifty pounds, no positive rule can be deduced from this statement.—During harvest time, when every operation is pushed forward, four good horses can easily draw 3,500 lbs. weight ; and, provided that the wagons are of a proper size, the roads good, and the distance not too great, they may be made to draw 4,000 lbs. weight. If the sheaves are all of a certain size, it will then be easy to calculate what number of them will form a wagon-load. In hay harvest, a wagon drawn by four horses will scarcely be able to carry twenty-two or twenty-four quintals, on account of the room it occupies ; and as a great deal of time is lost in loading and unloading, and as this work cannot be commenced very

* To this description of plow belongs an instrument for heaping the mould taken from the middle of the furrows round the plants sown in rows. [*French Trans.*

† The author makes no mention here of the machines for sowing corn which are used in France and Switzerland, and which sow the seed in rows about five or six inches apart, (from 14 to 16 centimetres.)—Although these implements extend over a space of 2½ feet or 81 centimetres in breadth, the greatest extent of land that can be sown with them by the aid of a single horse does not exceed four or five acres. [*French Trans.*

early in the morning, it is impossible to get in more than six or eight wagon loads per day, even when the meadows are very near the homestead.

The operations of which we have been speaking, belong to particular seasons and times of the year; we will now proceed to mention others which are applicable to any seasons and may be performed in all kinds of weather.

6. *The carriage of grain and other product to the market towns.* It is generally allowed that 24 bushels of winter grains and peas, 32 bushels of barley, and 36 or 40 bushels of oats may be placed in a wagon at the same time. If the distance is about four or five miles one day is allowed to go, another to return, and a third to load the wagon and sell its contents; if the distance be six or eight miles, three days and a half are allowed; if three miles, two days; and if two miles, one day. Thus, the distance of the market town makes a great difference in the performance of this operation, which is always exceedingly prejudicial to the teams.*

We shall now divide the year into four seasons, without, however, confining ourselves within the limits prescribed by the calendar.

Thus, winter comprises eighty days of labor, which may be employed as follows:—

Carrying manure for the fallow and vegetable crops, and breaking up some of the stubble fields, if the frost is not too hard to admit of it. After this is done, the teams may be used for any other purpose.

Spring comprises sixty-four days of labor, during which the following operations must be performed:—

Giving the second, third, and even fourth plowing and harrowing to the fallow crops; giving the vegetable crops one plowing; the barley one plowing; the oats one or two plowings. The last two operations may be in a great measure saved, or at any rate diminished by the use of the extirpator.

The newly-made dung must be carried to the last planting of the fallow crops, the winter corn harrowed, and those operations performed with the horse-hoe which are designed to encourage vegetation.

Summer, which commences somewhere about the month of June, comprises eighty days of labor, which may be be thus employed:—

Plowing the fallow ground for the reception of the winter grain; plowing the stubble of clovers and leguminous crops the first time, in order to prepare for the autumnal seeds. Carting the manure destined for the winter crops; continuing the use of the horse-hoe from time to time; getting in the hay harvest, and reaping and housing the corn.

Autumn, which we suppose to commence in September, comprises seventy-six days of labor, and the following operations:—

Plowing and harrowing the seeds; cutting and gathering the after-grass; getting in the potatoes and other roots, and also the cabbages; and breaking up the stubble-fields or pastures, not only for the reception of the seed of the following spring, but also for the dead fallow of the summer.

Those who are accustomed to agricultural operations will be able to form an exact estimate of the number of teams which will be required, and to ascertain from calculation or past experience how many are necessary for the seed time of spring and autumn, in order to execute the work in four weeks or twenty-four days in the best possible manner. If a plow drawn by two horses can plow two and one-third acres of ground per day, and if four horses can harrow sixteen acres a day, a team consisting of four horses will be able to sow ninety acres per month; but if, on the contrary, from the tenacity of the soil, the increased severity of labor, when a greater depth of furrow is performed, or from the inadequacy of the force and slow motions of the horses, only two acres per day are plowed, the number of those which are sown will be reduced to seventy-six.—Thus, for each extent of ninety or seventy-six acres of spring or winter sowing, (or, according to the most general usage, for every 112 or 95 bushels of seed,) a team of four horses must be kept. In many countries a horse is kept for every *winspel*† of autumnal seeds. But when an extent of ground is sown with oats and barley equal to that sown with wheat and rye, and a quantity of vegetables and fallow crops is likewise cultivated, it will be impossible to execute all the

* A German short mile is equal to 3·897 English.—[*Eds.* † A winspel is equal to 24 bushels of English measure.

operations incidental to spring with the same number of beasts as would suffice for the autumnal seed time.

Manual Labor.

In some few agricultural undertakings, laborers are employed in those operations which are executed by oxen; when this is not the case, a herdsman can take care of twenty-four or thirty oxen; but where a still greater number of these animals is kept, he will require a lad to help him.

One cowherd is sufficient for fifty or sixty beasts, not only while they are at pasture—for then, with the assistance of a good dog, he might easily take care of two hundred—but also when they are in the stable, if some of the other domestics will assist him to cut the straw in the winter, and if the green fodder is cut and brought to him in the summer.

The number of female servants must be regulated by the number of cows that are kept, and also by the quantity of milk which these animals yield.

These servants are employed not only in milking and taking care of the dairy, but also are required to assist as much as possible in the cultivation of linseed, hemp, and other products, and in the harvest time: and in the winter they spin. When it is necessary to pay great attention to stall feeding, three female servants are allowed for every fifty cows, with one to inspect the others. In some countries, where great numbers of these animals are kept, one maid servant is allowed for every ten cows; but then she is expected to feed them and carry away their dung, two things which in moderately extensive establishments can be much better accomplished in another way. Most of the great cow-keepers in Holstein and Mecklenberg keep only one milk-maid for every twenty-five cows.

In large farm-houses, another female servant ought to be kept for the performance of the domestic affairs.

A man must also be kept to look after and take care of the pigs; this is not, as is generally supposed, so insignificant a duty that the execution of it may be confided to old women or to children.

We shall not mention the shepherd and his assistants until we come to treat of sheep, because the manner of using these servants and the wages which they receive vary greatly in different places. The shepherd is seldom included in the calculations of rural economy, excepting thus far, that he receives a salary either in money or in produce.

Besides the servants already mentioned, a bailiff or overseer is frequently kept, whose place it is to inspect all the operations, whether in the fields, the out-houses, or at the farm; to superintend the plowing, the seed-time, and the harvest; and to use vigilance that all the laborers do their duty. He ought, also, to look after all the agricultural implements, and to be able to repair them and make new ones. In very extensive rural establishments, another overseer or bailiff is also kept, whose duty principally consists in making and repairing the carts' and wagons' work, and in superintending all the repairs and smaller buildings. Sometimes one or more extra farm servants are kept in readiness to assist in any operation for which they may be required; but, in general, day-laborers are preferred where it is possible to procure them.

Where these house servants are single, they generally live on the farm, and are boarded, lodged, and provided with every necessary article; but if they are married, they reside in separate habitations, and are allowed a certain quantity of provisions for their subsistence. The former are, certainly, most advantageous to the farmer, both as regards expense and the power of exercising a proper degree of surveillance over them. The greater the number of servants kept, the less is the expense of each individual one; for the cost of lodging, fire, candles, and even food, is almost as much for two or three as for twice that number. Where there are only a few servants kept, it might be advantageous to give to each one his allowance in produce.

There can be no doubt that the fewer married servants and those who receive their allowance in produce are kept, the better; for they invariably contrive that their whole family shall live at the master's expense, and are seldom or never satisfied with the provisions allowed them, although these may be far more than they could possibly require for themselves, but endeavor to carry off all that comes in their way; and it is no easy matter altogether to prevent their having

the opportunity of pilfering.* Nevertheless, as some situations—those of bailiff, herdsman, and cowherd—require to be filled by steady, middle-aged men, and these are seldom to be met with unmarried, the farmer must, therefore, submit to the necessity of paying them their maintenance in produce.

No general estimate can be given of the expense of the keep of a man or maid-servant, on account of the numerous variations which are produced by locality or by different customs. The difference of expense in one country or in another is so great as frequently to increase or diminish by one-half. In general, however, it will be found, that where the servants are well kept, and particularly where they receive an ample allowance of food, they are stronger, more capable of work, and more willing to assist in all kinds of operations, so that the value of their labor is very little short of the actual cost of their keep. Accounts of the usages of many countries with regard to servants, and specifications of their expense in these places, will be found in many treatises on agriculture and political economy. None of these calculations are, however, to be depended on; the most correct are those by Count Podeevils à Gusow, in his work on political economy.

According to an average rate deduced from observations made by myself in countries which are well known to me, it appears that the expense of the keep of a man-servant, a dairyman, or a cowherd, ought to be about equal in value to 34 bushels of rye, or 272 ‡; and the expense of a female servant, or lad, to 28 bushels, or 224 ‡: every necessary expense, as fire, candles, bed, &c., is comprised in this valuation. The difference is great in money, on account of the difference which exists in the price of provisions.

The wages in money likewise vary greatly; nevertheless they are generally more in accordance with the price of corn than with the nominal value of money: they may be estimated at 16 bushels of rye, or 128 ‡, for a man-servant; and 12 bushels, or 96 ‡, for a female servant; and this will include linen, clothing, and other articles which she is to receive.

The wages of an overseer or bailiff are generally a little higher, and those of a cowherd a little lower, than those of the other servants.

Other workmen are paid by the day, or by the task; that is to say, for a certain quantity of each kind of labor; or, lastly, by a certain portion of the produce of their labor.

If the farmer would have his day-laborers do their duty, he must follow them up from morning to night, and look very carefully after them. The men earn much less when they work in this way, and, nevertheless, any work thus executed is far dearer to the farmer. In general, a day-laborer who is employed on some simple operation, and works a moderate time, will earn a bushel of rye in eight days, and, consequently, we may say 1 ‡ per day. Women and young persons, or feeble workmen, will only earn a bushel of rye in twelve days, or 0 2-3 ‡ per day; but this calculation is also liable to variations.

It cannot be denied that this last-mentioned kind of work (task-work) is by far the most advantageous both to the farmer and to the laborer, for then the latter will endeavor to get on with his work instead of trifling away his time and husbanding his strength. He will, of course, earn more than if he worked by the day, and, consequently, will be better fed, and able to procure many comforts, and to preserve his health and strength. He will, therefore, feel more interested in his work; will study how he can render the execution of it less difficult, will procure better tools, and acquire more skill, particularly if at certain seasons he is regularly employed in the same operations. His wife and children can frequently assist him, and by this means he will get on faster and train up his children early to work, and, by accustoming them to earn their own living, will thus relieve himself from some part of his responsibility.

* The author here prefers single to married laborers; the point admits much speculation, and, like most employments, the advantages of each are nearly balanced. It is evident that both must be employed; and while the necessity of having, on every farm, a ready command of labor is admitted, few farmers now-a-days like a number of servants living in the farm house. One or two seem useful, but a greater number is more advantageously removed to adjoining cottages. In our country, the single men on full wages are reckoned more expensive and much more troublesome than married laborers; and the author's observations about pilfering opportunities, are generally shifted to the other side. But our system of paying in a stipulated quantity of produce, to be used at pleasure, differs from the continental mode, where it would seem provisions are given for subsistence only, and exclusive of the value of labor. A somewhat similar custom yet prevails in the south of Scotland, where resident reapers receive a portion of grain in lieu of the evening meal, and thus is saved the trouble of cooking in the farm-house for that number.

So far from rejecting this mode of proceeding as some prejudiced agriculturists have done, because they feared that their laborers gained too much by it, although at the same time they could not help perceiving that the work done in this way cost them less money, a clever and clear-sighted farmer will not allow himself easily to be deterred from engaging his laborers by the task for performing all those operations, the value of which can, in some measure, be calculated beforehand. Threshing is one of those operations in which the laborers are paid by a certain portion of the produce of the work; the threshers generally receive the 14th, 16th, or 18th bushel of the produce. The same system is applied in some places to harvest; and in this case the reapers receive the 11th, 12th, or 13th sheaf for reaping and performing all other portions of this operation.*

In order to calculate the number of day-laborers or task-workmen which will be required in an agricultural undertaking, the following operations must be estimated, as being of most frequent occurrence:—

Plowing with oxen or horses, if only one man is kept for every four-horse team.

Harrowing with oxen. When the number of horses is short, it occasionally becomes necessary to employ oxen at this work; likewise for wagons drawn by oxen, if there are no servants who can be entrusted to drive.

Manuring and ameliorations; carrying manure from the stables and cattle-sheds; watering it, turning it, &c. Two men and a half will generally be required to load each dung-cart, but this will, in a measure, depend on the rapidity with which the carts are driven backwards and forwards, the distance they have to go, and the compactness of the dung. The driver alone can generally unload the dung-cart; if, however, several teams are used in the same cart, it will often be found advantageous to employ a man to assist in this operation, and, at the same time, to see that the heaps are properly distributed over the ground.

Spreading the dung on the land. It is generally admitted that a woman can spread an acre and a quarter per day, and a man an acre and a half or two acres per day. But this depends much on the quantity of manure which is to be spread, and on the state of it, and on the care which is taken to divide it as much as possible and distribute it equally. This last mentioned point is of so much importance, that no pains should be spared in attending to it. Manure containing much straw often requires to be thrown into the furrow with a rake or pitchfork, and this operation requires a man for two plows, and sometimes even for one.

Sowing. This operation is usually performed by the head-man. It is generally reckoned that a man can sow eighteen bushels of winter grain and twenty-four bushels of spring grain in a day.† A skillful sower can, in fact, sow much more if the extent be taken as a guide for the quantity of seed; this, however, depends on the thickness with which the seed is sown. It frequently happens that, when the seed is sown too thickly, with a view of getting as much as possible into the ground in the course of the day, a great quantity is lost. Attention should, therefore, be paid rather to the extent of ground sown than to the quantity of seed used; and if a man sows fifteen or sixteen acres per day, that should be considered as sufficient.

At harvest time, it is usually reckoned that with a cradle, (a scythe furnished with rods for collecting the corn in heaps at the same time that it is cut,) each man can cut and heap two and a half acres per day: a woman is supposed to be able to rake, bind, and collect two acres a day. Strong active people, who work hard, can, however, get through one-third more. The average amount may be reckoned as a little higher when an ordinary scythe is used. A man using a sickle may reap an acre a day. If the fields are not at a considerable distance from the farm-yard, the crop may be housed very rapidly by means of relay wagons; each wagon will require two men to load it and one woman to rake; but only one man beside.

* The author much approves of task and piece-work in all cases where circumstances permit, though the utility is much disputed by many extensive practitioners, as tending, in most cases, to produce a careless performance of work on the part of the laborers, in order to realize more wages in a given time. For much of the detail work of a farm, task-work is unsuited; it is generally applicable in operations that require a very quick execution; and especially in cases that admit a regular and easy inspection; the preference, however, would seem to be yet undecided between laborers paid by the piece of work that has been satisfactorily executed, and workmen who perform, under constant inspection, an equal quantity. Our own opinion leads us to give the preference to task-work, wherever it can be adopted.

† A good seedsman with us will sow more than double this quantity.

Two men are required to unload and two to stack the corn when the crop is brought home quickly, besides three women for every ten feet of depth in the stack. If the wagons only return at considerable intervals, two men will often be sufficient. When the stubble is torn up with a horse-rake, one man and one horse can usually get through ten acres per day.

Hay harvest. An acre and a half is the usual allowance for each mower, and the same for each haymaker.* When, as frequently happens, the meadows are at a considerable distance, the calculation must be made lower. The weather makes a very great difference in the number of people required for hay-making; in fine weather not nearly so many are needed. In mowing clover, where the land is very level and the clover has not been beaten down, two acres and a half may be reckoned for each mower; and as the manner of executing the work is very simple, one laborer may be considered as sufficient for four acres.

The same number of men as are required for the corn harvest are usually allowed for loading and unloading, and half as many in the barn or hay-loft.

The methods adopted for the cultivation of the fallow crops, differ very much. If it be performed with the proper implements, and in a manner which is at once the best and the least expensive, one acre will employ the following number of laborers: two for sowing potatoes, one for rooting up those weeds which remain after the use of the horse-hoe, and one man and eight women for gathering the crop.

For sowing radishes and other small seed in rows: one man can sow five acres per day with a small sowing machine; and two men can, with the assistance of a horse, plow the furrows over twelve acres in a day. Two persons, a man and a boy, are generally employed in sowing beans in rows, in order that the operation may be the sooner completed; they can get through five or six acres a day.

The weeding and thinning of radishes sown in rows should always be considered as task work. In these parts three pfennigs are paid for forty perches long, and the man who does this kind of work earns five or six groschen per day; consequently he thins about an acre per day.

If the farm servants are not sufficiently numerous to allow their feeding and looking after all the cattle, and especially if the cattle are partly fed upon chopped straw, some day-laborers must likewise be kept; the number, of course, will depend upon the peculiar circumstances of the establishment. Sixty or seventy days' labor are generally allowed for the washing and shearing of a thousand sheep.

Day-laborers are also required for various kinds of work in the farm-yard and the household, unless there is a superabundance of servants. It is also occasionally necessary to employ them in the room of those servants who are ill.†

For the cultivation of the garden, which we will suppose to be conducted on the simplest possible plan, and in which the female servants can be made to assist, five days' work of a man may be yearly reckoned for every acre.

For taking care of the ditches and trenches, repairing fences and damages of all kinds, and keeping the roads in order, from half a day to one day's work per acre all over the estate may be reckoned. This will, however, depend upon the extent and number of the fences, roads, and ditches.

It is impossible to form a general calculation of the amount of work which will be required for improvements, but the laborers may be employed on them at those times when there is least work to be done.

Threshing is usually considered as task work, and is paid for by a certain portion of the produce of the labor, generally a sixteenth part.

It is, of course, understood that these data are subject to variation, and that they may be increased or decreased by the skill and activity of the laborers, the manner in which the work is arranged, and many other causes. They comprise the work which may be expected from a day-laborer, but are by no means equal to what a strong active man can do, or what a laborer working at task-work will perform.

* These calculations must be made in reference to crops much lighter than the average of England.

† Some of the quantities of labor here mentioned as being performed by a certain power in a given time, are greater than the usual rates in our country, and many of them are smaller. Such differences will arise from local peculiarities of soil and climate, and also from the implements and mode of culture. Our shepherds would not require sixty or seventy days to wash and shear 1,000 sheep.

We stated before, when speaking of draught-labor, that if the teams were sufficiently numerous to get through the sowing time, they would suffice for the whole year; and so it is with regard to manual laborers, if the number is large enough to secure the harvest properly, they can accomplish all the other necessary operations. The laborers who have been employed at this season, may, in a large farm, be retained all the year round.

THE PROPER METHOD OF KEEPING THE JOURNALS, REGISTERS, AND OTHER BOOKS CONNECTED WITH AN AGRICULTURAL UNDERTAKING.

A clear, precise, and accurate system of book-keeping is an essential feature in an advantageous and well-arranged agricultural undertaking. The most perfect system and the longest course of practice, even though acquired in the very place in which the cultivation is carried on, are rarely sufficient in giving an unexceptionable view of all its various relations and actual results. The farmer, in order to be convinced that he is really making some little progress towards the attainment of perfection, should always have before his eyes such a comprehensive view of the system as is naturally presented by well-kept books. In a too complicated system, the impressions of the senses and the recollections left by them seldom or never indicate the combinations which, on a former occasion, tended to produce the desired end, with sufficient exactness to be depended on; and, consequently, it is impossible accurately to say which were those that required to be modified or undergo a complete change.

The system of book-keeping may be divided into two parts: the one permanent, the other annual.

To the former belongs what is called the *estate-book* (*livre foncier*). This book should contain a plan of the whole estate and of each of its useful parts, and present a full, clear, and precise enumeration of every circumstance relating to it.

Above all things, this book ought to contain plans, with explanations of them. There are three sorts of plans: 1, The *geometrical plan*, containing the measurement of the surface; 2, The *geological plan;* and 3, The *plan of the distribution of the portions of land assigned to the different rotations of crops*, and the differences in the soil that cause the arrangement. In time, these three kinds of plans may be united; they are however, designed for different purposes, although referring to one another; and it is therefore advisable to keep them separate and distinct.

1. The *geometrical plan* is merely a map of the extent of the surface, its permanent and natural divisions, and its limits. There is no reason, however, that certain notes and remarks should not be inserted in it, which may be useful; and the boundaries and the principal isolated trees may likewise be marked.

2. The *geological plan* shows the variations which exist in the nature of the soil. The various species of soil may be indicated on this plan by different colors, which will serve to show their extent, and to point out the places in which the nature of the soil is either suddenly or gradually changed. Where the variations in the nature of the soil are considerable, and the changes occur very near to one another, it is necessary that this plan should be drawn on a much larger scale than either the first or the third; and in fact, that a separate sheet should be devoted to each piece of land. Such plans may be of very great assistance to the memory in arranging the system of cultivation; but, for this purpose, particular attention must be paid to the degree of humidity of the soil, and the places in which the moisture is very abundant must be marked in a distinct manner, as well as those which are most hurt by drouth. These plans should present the nature of the soil and its physical properties in every part of the estate at once to view, in the clearest and most obvious manner, and with mathematical accuracy.

3. The *plan of the distribution of the portions of land assigned to each rotation of crops.*—This plan contains the division of the estate and of its several parts, relatively to the kind of cultivation to which they are to be subjected. It should not be confined simply to the division of the crop-lands, but should extend to all the sub-divisions, particularly if they are to have any influence on the nature of the produce. It might, perhaps, be advisable to mark in it single acres or patches of land, where the expenses of the tillage, manuring, and sowing

these portions are to be separately calculated. The numbers of the principal divisions may be marked on this plan in Roman numerals; and those of the sub-divisions, or of these pieces of land, in Italic figures, or by simple letters. A new series of numbers may be formed at pleasure for the fractions of each allotment of land, or the same series may be continued throughout all the pieces comprised in the estate. If it be desired to unite these three kinds of plans into one, that one must be formed upon a tolerably large scale, in order that each separate division may readily catch the eye.*

In many cases, and especially in very mountainous situations, where it is necessary to provide against water, it may be very desirable to have a leveling sketch taken of the land in various directions, and to exhibit a plan of it in a diagram. The nature of the beds on which the vegetable mould rests, and likewise those of the most remarkable of the lower strata, may also be indicated in this diagram.

To these plans tables should be affixed, showing the nature and consistency of the soil in each of the parts, and the distribution of the lands for crops. These things may all be comprised in one single table, which will thus give a clear and exact idea of them. If the division of the crop-lands be fixed and permanent, each division ought to have its own separate table. In the first vertical column there will appear the sub-divisions, with their numbers and denominations.—Each kind of land should have a column assigned to it, in which the number of acres and fractions of acres which it contains should be indicated. The motives for classing the different soils should be stated by means of notes or references.

If, in the crop-lands, or their sub-divisions, there should be any low places which cannot be sown, as bogs, ditches, roads, or other spots which will not admit cultivation, the extent of such places must also be specified; and the sums will then be taken both vertically and horizontally.

Besides this table, a separate description of each field should be drawn up, exhibiting all its peculiarities.

If every species of land be taxed for the purpose of affixing to each division and to every one of its sub-divisions a price proportionate to the relative value, a summary will be obtained which will prove very useful in forming a valuation of the effective produce. Thus, after having previously deducted from the capital the value of all the rights and accessory revenues, independent of these lands, an estimate of the value of an acre of each sort of land is made according to the nature of the soil, and by the rules which we shall lay down when treating of agronomy, and, as far as possible, in proportional numbers; for example, the first class land may be estimated at 10, the second at 8, the third at 6, the fourth at 4, the fifth at 2, and the sixth at 1, if that be the proportion which they bear to one another.

The value of each division or sub-division of crop-land is thus determined according to the quantity of each class which it contains, and this estimate may be used in forming a precise valuation of the net produce of each portion, as is the custom in England. It is generally known that the crop on any given surface is better in proportion as the soil on which it grows approaches the middling class.

In this valuation of the land, or rather in this division of capital among all the lands of which the estate is composed, some notice ought to be taken of other considerations totally foreign to the nature of the soil; thus, a field at a considerable distance from the farm buildings may be estimated at a much lower rate than one which is nearer, supposing them both to be of equal fertility.

The value of each portion of land thus determined may also be added to the table in a particular column.

It will be understood that meadows, pasture-lands, woods, mossy ground, and

* The maps and plans here recommended by the author are essential to the proper management of estates, and form a striking contrast with the careless and unsystematic manner in which such means are generally used. A general cash-book and a geometrical map are usually kept from necessity, but the geological map and the book of rotations on the different soils, mentioned by the author, are found in some few instances only. The two latter are intimately concerned; and, when properly arranged and kept, are attended with much advantage. The map should exhibit the different strata, and all the variety of soils incumbent on them; and the book of rotations should contain a reduced geometrical map of each farm, facing on the opposite page a tabular form of the different fields, with the crops grown on each during every year of the lease. The wood, on extensive properties, may be reduced to a similar form; and, by these methods, correct views can be at any time obtained of all circumstances relating to the estate, and very useful inferences and suggestions may be deduced for the future management and improvement.

other useful kinds of land, should be included in the estimate as well as the arable lands, and their portion be charged in the distribution of capital.

With regard to the buildings, the value of which is usually added to the capital of the estate, if a separate value has been assigned to them, I think it most advisable to annex it to that of the lands which are in a state of cultivation, because it is for those lands that the buildings are required, and the latter are included in the conditions of the lease of the former. A complete specification and valuation of the buildings should be inserted in the *estate book*.

The *estate book* likewise contains an exact specification of all the useful and available rights that are attached to the domain, and the revenues, both certain and casual, which belong to it; such as statute-labor, tithes, leases of mills and taverns, incomes derivable from breweries and distilleries, or the right of having such establishments, and perhaps of supplying a whole district exclusively from them. The revenues are estimated according to their actual return, and the rights only according to the value which they would yield independent of risks, and supposing that they were farmed by another person instead of being exercised by the proprietor himself; for the profit which can be derived from a brewhouse, a distillery, or a mill used by the proprietor, is not so much the rent of the ground as the produce of industry. If such an establishment is really worked by the proprietor, a particular account of it must be inserted in the great book, and the rent alone which could be derived from it without the application of any labor, must be added to the capital of the estate.

The capital of the estate is composed of the united value of these different objects. If the amount of this capital be previously known, it must be distributed among the various branches according to their relative value, but not before a deduction has been made of all the liabilities of the estate according to the fixed or average value.

It will be found very useful to combine an account of the capital as well as an annual account of the cultivation with the estate book, in order to ascertain the return which the capital annually produces, and, consequently, the degree of augmentation which the property of the landlord acquires. According to the method of book-keeping by double entry, the annual interest of the capital of the estate and of the stock are added to the debtor side of the account in the estate book, together with whatever may have been expended in money; and the amount of that which has been delivered to the proprietor both in money and kind, whatever has been expended in permanent improvements or ameliorations, or the additional value thus bestowed on the estate, is carried to the credit account. As the determination of the last object may, in some cases, prove rather difficult, it is generally considered sufficient to reckon the expenses occasioned by these improvements, or the value of the labor which has been devoted to them, even when that labor has been executed by means of the ordinary resources of the establishment. Since these improvements increase the capital applied to the estate, the interest of their value should be added to the ensuing year, but at a higher rate. Thus, for instance, if the interest of land be reckoned at 4 per cent., that of the improvements in question must be estimated at 6 per cent.—This account in the *estate book* ought always to agree with that of the capital kept in the yearly ledger. It may be drawn up in the manner indicated on the following page:—

ADMINISTRATION OF THE ESTATE.

Debtor.	Rix-dol.	Creditor.	Rix-dol.
1843 to 1844.		1843 to 1844.	
Interest of 100,000 rix-dollars purchase money at 4 per cent....................	4,000	Paid to the proprietor......	1,200
		Expended in improvements	3,800
1844 to 1845.		1844 to 1845.	
Interest of purchase money at 4 per cent............	4,000	Paid to the proprietor......	3,500
Improvements at 6 per cent.	228	Expended in improvements	2,000
1845 to 1846.		1845 to 1846.	
Interest of purchase money at 4 per cent............	4,000	Paid to the proprietor......	4,000
Interest of improvements, 5,800 rix-dollars at 6 per cent....................	348	Expended in improvements	1,600
1846 to 1847.		1846 to 1847.	
Interest of purchase money at 4 per cent............	4,000	Paid to the proprietor......	6,550
Interest of improvements, 7,400 rix-dollars at 6 per cent....................	444	Expended in improvements	800
1847 to 1848.		1847 to 1848.	
Interest of purchase money at 4 per cent............	4,000	Paid to the proprietor......	8,500
Interest of improvements, 8,200 rix-dollars at 6 per cent....................	492	Expended in improvements	500
	21,512		
Balance due to the administration....................	11,138		
	32,650		32,650

Lastly, the estate-book should contain a history or chronicle of the estate, to which may every year be added whatever tends to influence its value and its rights. One of the most important items in this chronicle is an account embracing even the most minute details of every improvement that has been made in the property, and which has added to its value, as explained in a previous page. To this may also be added notes relating to the price of produce, the weather and the fertility of different years, and, indeed, to everything connected with the estate, or which may be interesting to be kept in remembrance.

All changes of any importance, whether in the divisions of the land, in the buildings, or in the revenues and privileges attached to the estate, should be carefully entered in the estate-book, care being taken to class them all under their proper heads.

Remarkable facts, observations, and experiments relating to the cultivation of the land, may likewise be recorded in it, where a separate book is not kept for that special purpose.

A book of this description becomes a kind of treasure which a man may bequeath to his successors.

The second plan of Agricultural books or journals contains the annual accounts of the whole undertaking, comprising the yearly account of the rural economy and the various matters relating to it. This system of accounts is complete in proportion as it extends to every portion of the establishment, embraces all the details which may tend to influence the whole, and exhibits each particular object with clearness and precision. It should, therefore, not only specify the disposal of the money and the produce in receipt and expenditure, but also contain details relative to labor, and all other matters which may tend to affect the success of the undertaking; as, for example, seeds, manure, &c. This system of accounts cannot be too carefully attended to and kept, as it is indispensable to the undertaking. The highest degree of excellence can never be attained without its aid: at all events, it is impossible without its assistance either to be sure of having attained the desired end, or to obtain a guide which will point out the path most likely to lead to it.

The following is the method usually adopted:—

Besides the *day-book* and the *note-book*, three *ledgers* are kept;

1. For the money accounts.

2. For the account of the receipt and delivery of produce.
3. For the buying, selling, and the profit or loss on the live-stock.

No. 1. The first part of the book containing the money account usually contains the receipts, and the second the expenditure. In both parts the pages are ruled in such a manner that the first column on the left may contain the date of the month and day; the second, the numbers of the vouchers if there be any; and the third, or middle column, the statement of the items; and the last two on the right, the cash accounts. In the first of the money columns, the various items are separately inscribed; in the second, the total receipt and expenditure of the month is inserted.

In order to explain the method more clearly, I shall transcribe the receipt of one month in the following table, whether arising from revenues in money or from the sale of rye:—

Date.	Vouchers	CASH RECEIPTS.	Rix	Gr	Pf	Rix	Gr	Pf
July 1.		Balance in hand..........................	210	16	8			
		For natural hay sold to ——, of ——,.......	64	13				
		For ground rent from the miller N——,.....	4	18				
		For ground rent from the farrier G——,....	3					
		For the letting out of land as potato ground, according to the account kept in the book for that purpose..........................	12	12				
		From the miller and farrier for money paid on their acount to the fire insurance office..................................	6	18				
		Total for July................	..	..	..	300	3	..

Dates.	Wspl	Sch	Metz.	SALE OF RYE.	Rix	Gr	Pf	Rix	Gr	Pf
Jan. 1.	3			To the miller N——, of ——, at 3 rix-dollars..........................	216					
7		16		To the bailiff ——, of ——, at 3 rix-dollars, 4 gr......................	50	16				
15	8			To the corn-chandler ——, of ——, at 4 rix-dollars.....................	768					
23		1		To the day laborer N——, at 4 rix-dollars..........................	2					
					..	..	..	1036	16	..

The items of the receipts in cash vary according to the plan of operations which is pursued; they are united or kept separate, according as it may be required to have a more or less distinct view of each presented individually to the eye. Each part has moreover, its peculiar title; they are usually classed under the following heads:—

1. Cash receipts, or revenues.
2. Sale of grain, each kind separately, as wheat, rye, barley, oats, peas, lentils, millet, and buckwheat.
3. Clover-seed, flax, and other kinds of seed and produce destined for sale.
4. Fruits, and other garden and orchard produce.
5. Sale of cattle, horses, cows, oxen, calves, pigs, sheep, and poultry, each on a separate folio.
6. Sale of animal produce:—
   (a) Butter, cheese, and milk, from the dairy and cheese-house.
   (b) Wool and lambs, from the sheep-fold.
   (c) Honey and wax, from the bee-hive.
7. Sundries—occasional receipts which do not come under any of the heads, such as the repairs of damages, &c. &c.

If any brewery or brandy distillery should be attached to the establishment, and its produce sold, an account of it must likewise be kept; but where concerns of this kind are conducted on an extensive scale, it is customary to assign to them a separate set of books, and a separate cash-box.

The second part, or pecuniary disbursements, usually include the following items:—

1. Payments to the proprietor, or on his account.
2. For building materials.
3. For builder's work.
4. For gardener's work.
5. For farm labor.
6. For labor expended on ameliorations and improvements.
7. For servants' wages.
8. For iron and nails.
9. For timber for use.
10. For fire-wood and turf.

11. For revenue in wood.
12. For horses.
13. For horned-cattle.
14. For pigs.
15. For sheep.
16. For farrier's work.
17. For cartwright's work.
18. For locksmith's work.
19. For harness-maker's work.
20. For cooper's work.
21. For carpenter's work.
22. For customs and port duties.
23. For messengers, drovers and traveling expenses.
24. For excise, turnpike, and city tolls.
25. For taxes, direct and indirect, poor-rates, &c.
26. For fire-insurance.
27. For produce consumed in the household and on the establishment.
28. For sundries, which cannot be ranged under any of the preceding heads.

The annual summary of the receipts and expenditure in each separate month, and of each description of article or item, is best made in the form of a table, which may be readily formed by the farmer.

No. 2. The ledger for the receipt and delivery of produce accounts, has separate columns for the different kinds of grain, and in these columns the receipts and expenditure are balanced every month for the purpose of ascertaining the quantity remaining in the store.

In this manner, the table in question supplies the place of a barn register; it is, however, usual to add to the amount of the receipts the produce not obtained from the harvest of the farm, such as corn purchased or received in payment for rent, &c.

Next comes the expenditure of the various kinds of grain classed under all the different heads. This account may as well be thrown into a tabular form.

The kinds of grain intended for sale may also be arranged in a tabular form.

The value in money may be given here by way of additional information; it is more fully and precisely stated in the money account.

Then should follow the other items of expenditure under their several denominations. Then the payments in grain, such as those appropriated to the physician, surgeon, veterinary surgeon, and chimney-sweeper; and lastly, the produce assigned for the consumption of the various persons employed on the establishment, such as the steward, foreman, cow-keeper, and shepherd, and also the farrier, if an agreement can be made with him for shoeing the plow-horses.

The corn consumed by the plow-horses may also be shown in the form of a table. If the account only relates to an establishment which is the immediate property of the landlord, separate columns must be assigned to carriage and riding horses, and to those belonging to visitors. Corn given to other animals must likewise be taken into account, and entered in columns under the head of fattening of pigs and poultry. A separate column is devoted to the important object of the sowings of various kinds of grain, together with a memorandum of the day on which the seed was sown and the piece of ground occupied by it. Each kind of grain should have a separate folio.

The corn-account is usually terminated by a specification of the number of sheaves that have been gathered, and likewise of the barns and stacks in which they have been deposited.

After the receipt and expenditure of grain, there follows the account of other kinds of vegetable produce, such as meadow-hay, natural and artificial, potatoes, radishes, carrots, cabbages, hemp, flax, poppies, &c.

No. 3. The ledger for the account of the increase and diminution of the live stock, contains, in the first place, a specification and description of every head of cattle, with its name, number, the species or breed to which it belongs, its age, qualities and defects, and the value which it possesses at the termination or renewal of the early account.

The opposite page is left vacant for the insertion of observations, which it may be necessary to make upon each animal in the course of the year.

The condition of the other kinds of live stock should be stated, as far as possible, in the same manner.

Next may follow the account of the increase and diminution of the live stock, the numbers of which ought to correspond with those of the inventory of the stock. A separate account is usually devoted to the sheep-fold, in order that the increase and diminution of these animals may be visible at once. This is par

ticularly necessary where the flock is composed of animals of different breeds, or where it contains some that are cross-bred.

Then may follow the account of the receipt and expenditure of various animal products; as, for example, what has been obtained, consumed, or sold, in butter, cheese, milk, wool, eggs, honey, wax, &c. The skins of beasts killed for home consumption, and likewise those of sheep that have died, or have been killed, should likewise be entered in their proper places.

This method of book-keeping is, of course, subject to a variety of modifications. Every one may arrange it according to his personal convenience, or to the end which he has in view.

It constitutes, however, the system which is most approved at the present day, and is perfectly sufficient for all the wants of an ordinary system of agricultural operations. At the close of each monthly account, it exhibits a clear view of the whole; and as it may be supposed that every person who is employed to inspect a set of agricultural books must be more or less acquainted with it, a director will be better able to justify his conduct by it than by any other means.

The preference bestowed on this system, by many persons, on the plea that it is easier and more simple than any other, appears to me to be more founded on habit, and on the practice which these persons have had in the use of it, than on anything else. Besides, this system of book-keeping is by no means remarkable for simplicity, since it requires the use of several books and the double insertion of every item, and is by no means easy of reference. Besides, it does not give a clear idea or view of the details of the management and cultivation.

One of its greatest defects is the want of a simple and precise mode of reckoning in one of the most important objects of rural economy, viz., the application and division of labor; it is, however, possible to keep a book for this particular purpose. We shall very soon have to speak of the method of keeping an account of labor.

Before proceeding to the description of other modes of book-keeping, it will be as well to pause and endeavor to settle the question as to the time of the year at which the accounts should be opened or closed.

Many and very different periods have been selected for this purpose. The best is undoubtedly, that in which there is a pause or rest, and when the greater part of the produce having been sold or consumed, the remainder can, consequently, be the more readily estimated. The usual commencement of the year is not, therefore, convenient; neither is the spring or the autumn, in my opinion, the proper season. Where I live, the 1st of July is the time usually chosen; and it appears to me to be on many accounts more suitable than those before mentioned. I do not, however, like to see the hay-harvest thus divided into two parts, and therefore prefer the beginning of June; because, at that period, most of the things which require particular attention are in a state of rest; and there is then most leisure for a careful examination of the state of the provisions, the stock, and, indeed, of every part of the rural economy. There may, however, be many motives which will induce a person to conform in this respect to the usages of the country in which the estate he farms is situated, and particularly to that period at which farm leases usually commence and expire.

Where it is customary to sow small barley in June, the beginning of July certainly is the best time.

Although labor is one of the most important items in Agriculture, much too little attention has frequently been paid to taking notes of it, and calculating the expense. Even if a general estimate be made of the cost of plowing executed by the servants' and teams belonging to the estate, as well as by day-laborers and task-workers, and the whole amount of these expenses be obtained by adding together the wages and food of the servants, the value of fodder consumed by the beasts of draught, and, finally, the amount of pecuniary disbursements, still the portion of these expenses which appertains to each object, product, and field, is rarely ascertained with any precision; nevertheless, such knowledge is of the utmost importance, since it affords the only means by which certain results respecting the profit and loss of each department of the cultivation, or system of operations in general, can be obtained. Again, it is in this way alone that it is possible to ascertain whether the resources which have been expended on labor have been employed to the greatest advantage, or whether they might not be

better applied. The method of which we are speaking would, likewise, tend to give a greater degree of control over labor than could be obtained by any other means, and to furnish data for making valuations on far more certain principles than could be derived even from the most incessant and careful superintendence and inspection of the different branches of labor.

For this purpose it is chiefly necessary to take note of the various works which have been executed, whether by manual labor or by teams, and the uses to which they have been applied. The method of making this entry is by no means unimportant; on the contrary, it is of the greatest moment, both as giving the utmost facility to the inspector, and, what is of more consequence, as furnishing him with the clearest possible summary of the labor devoted to each object, and enabling him afterwards to transfer it to the proper place without risk of error. I have tried various forms of this table of labor, and am of opinion that a weekly table is that which answers the purpose best. The one I use contains columns for four different classes of laborers, who receive a daily stipend of 6, 5, 4, and 3 groschen. These sums frequently vary from one season to another.

In the first column, the description and locality of all the operations executed during the week is entered. When it indicates the locality, or the purpose to which the labor has been applied, care must be used to make the note in the table agree with the title under which it will have to be entered in the ledger.—Thus, those works of which it is desirable to have a distinct summary, must be entered separately in the table; while all those which are to be carried to the same account, may be collected together under one head. It requires some considerable degree of knowledge on the part of the inspector to form this combination properly; and, until this knowledge has been acquired, it will be better for him to make a number of distinctions rather than class too many subjects or objects under one head. At the beginning of the week he enters all those operations and works which he knows must certainly be performed; those others which he could not foresee, he enters, of course, in the order in which they occur. There can be no doubt that it is very desirable he should draw up a list or table of all the works which he knows must be executed; he will then only have to enter on every day the quantity of labor of each kind which has been expended upon every operation, in the proper column. The best way is to devote a book containing fifty-two pages to this journal, arranged in such a manner that the distinctions of heads will only require to be entered at the commencement of each quarter, and the divisions or columns are previously made.

Other persons may perhaps prefer having a black tablet, with horizontal and vertical lines drawn in red colors, and in such a manner as not to be effaced, suspended against the wall, and to mark the work which has been done each day upon it, and also the number of laborers employed in that work.

In the column which contains the summary, the number of laborers of each description employed during the week on each particular operation is inscribed; and in the money column the cost of each separate piece of work is entered.—The total amount of days' labor of each description, and of the money expended, ought then to agree with the number of day-laborers and the sums paid to them as wages.

If a portion of the work has been executed by statute-labor, or by gratuitous service, an account of it must be entered in the proper place, and the value of it united with the rest. At the end of the week when the accounts are made up, these days of gratuitous labor must be separated from those which have been paid in money. The statute-laborers are considered as creditors for the number of days' labor which they have performed, and the sum is deducted from the whole amount which is due from them.

The daily account of labor executed by teams is kept in the same manner.—Columns are assigned for each species of labor, separate ones being kept for the horses, the oxen, and the men who work with them. Each individual will be able to determine for himself whether it is best to make no distinction between or to separate the domestics who look after the horses, from those who take care of the cows. If the day-laborers work with the oxen and horses, their labor is entered in the table of manual labor and not in that of which we are at present speaking. The labor of beasts of draught is always better reckoned according to the number of head of cattle than according to the number of teams employed.

At the close of the week a calculation is made of the number of the days of draught labor that have been applied to each operation; I think the money column may be omitted in this table.

From these weekly tables it will be easy to form a monthly summary of the whole accounts. There is, however, no occasion to confine oneself to a certain number of weeks: all that is requisite will be to rule the columns sufficiently long to comprehend the period which they are to contain. On an open sheet, there is always room for eight weeks.

For my own part, I find in the method of book-keeping by double entry so decided an advantage over the tabular form, that I feel very much inclined leaving to others the trouble of bringing the latter to perfection.

There can be no doubt that it is absolutely necessary to reduce everything to one common standard; and it would be scarcely possible to adopt any other than that of money, since it is to money that all the products of industry are ultimately reduced. Nevertheless, in the course of the reckoning, doubts frequently arise as to the value which ought to be assigned to some things which cannot be immediately realized. It is true, that a false estimate would make no difference in the final result, since what was lost to the credit of one division would be added to the debt of another; but this mode would lead to inaccuracy in the value of particular items. The average price of the greater number of articles—such, for example, as the grain and fodder consumed on the establishment—cannot be accurately determined in the course of the year, and at the time when they are used; and yet it is this price which regulates the valuation of other things which cannot be immediately settled in money—as servants' labor, and the labor of the beasts of draught employed in each particular operation; whereas, at the end of the year, a due consideration of all the circumstances and relations will lead, with some degree of certainty, to a knowledge of the value of each separate article in money.

Thus, for example, if I know at what value I ought to estimate the oats and hay consumed by the beasts of draught, and if I am also acquainted with the accessory expenses incurred by them, I can tell what a day's labor of a horse or an ox costs me, and can thus carry this sum to the debtor side of the account to which the operation belongs in which they have been employed; supposing, of course, that the number of days' labor has been accurately determined. In order to conduct a valuation properly, it is only necessary to lay down certain fundamental principles, and adhere faithfully to them. If, for example, any one should choose to take the average market price as the basis of his valuation of corn, I see no objection to such a course, provided that he also deducts from this price the expenses of transport, estimated by their actual value; including not only the wear and tear of the horses themselves, but also of the harness, and a certain degree of disorder among the men employed, as well as various other accidents and circumstances which experience alone can foresee and guard against. Thus, if, from a train of accidental circumstances, the market price should be raised considerably above the natural standard, that is to say, above what might be expected from the abundance of the harvest, I should fix the consumption price by that which the abundance of the harvest would give when uninfluenced by other circumstances; because those things which have tended to modify the natural price have not the slightest connection with my system of cultivation. I should likewise proceed on the same principles with regard to hay. As to those vegetables which are cultivated exclusively for cattle, as potatoes, turnips, &c., I should estimate their price at one and a half times what they cost; that is to say, at one and a half times the united value of the ground rent, the manure expended on them, and the labor employed in their cultivation. If the price throughout the neighborhood should happen to become six times as high as its ordinary standard, it would make no difference to me or to the price which I had previously fixed upon the article in question appropriated to home consumption, because I could profit little by this increase of price.

I have hitherto estimated the price of dung at one and a half rix-dollars for a load of twenty quintals; I divide the total value between the cattle which have produced it and the straw which formed the litter of the animals to which it has been applied, assigning one-third to the cattle and two-thirds to the straw.

These are the principles which I have adopted for my own guidance with re-

gard to the determination of prices, but, of course, every person is perfectly at liberty to modify them according to his situation and circumstances. When there is no cash receipt and expenditure, the produce is provisionally carried to each account in weight and measure only; and, at the closing of the account, its value is charged to the money column.

Most persons, who keep separate accounts of distinct productions, are in the habit of uniting together the same kinds of produce, although grown in different fields; but this method is not sufficient for me; I wish to know what each field has cost me, and what it has produced. In my books, therefore, each field has its separate account, and if two or more different kinds of produce grow in the same field, each of them has a respective account. This method causes no extra difficulty, if the daily accounts of labor are carefully kept. It must, however, be remembered that the greater part of the expenses of harvest belong to the preceding year's accounts, since the new year commences on the 1st of June or the 1st of July. But as it is necessary that the expenses and the produce should be contrasted with each other in the same account, the former are taken from the preceding year's accounts, either in one sum, or, at most, under the principal divisions; they are thus charged to the debtor side of the current year, and to the creditor side of the preceding year.

The produce of the various fields in grain is first debited to the barns in sheaves: but I do not value these sheaves until after the threshing is over, at which time I am able to ascertain the quantity of grain which they have yielded, and the price which should be affixed to it. The barn account should be kept in this manner, in order that it may supply the place of a barn-register; I know no other method by which the produce of each field can be kept separate, supposing that I am anxious to obtain an accurate knowledge of it: such care and nicety is, however, quite unnecessary for those who only wish to ascertain the gross amount of the produce. The quantity which the sheaves are found to yield after threshing is then placed to the creditor side of the barns, and to the debtor side of the kind of grain to which it appertains. It is better, at first, not to enter anything beyond the number of bushels produced, and to defer affixing the pecuniary value until the price of grain has reached the average hight; and this amount may also be added to the general price adopted in that year for the rural economy: I shall call this latter the *cultivation price*, in order to distinguish it from the *current price* in the markets.

After the corn has been sold, the price actually obtained for it is entered, and the balance of the grain-account then shows exactly how much has been lost or gained in consequence of all the commercial circumstances.

The expenses that attach to grain, from the time of its consignment to the granary to that of its sale or consumption, cannot be charged conveniently to each particular kind; an account is, therefore, kept in the granary, containing, for example, the expenses of turning and cleaning the corn, and particularly the cost of transport. Should it be considered requisite or desirable, these expenses may be divided among the different kinds of corn in proportion to the quantity and pecuniary value.

There are also other matters which require particular accounts of cultivation and provision. The various expenses of cultivation are added to the debtor side of the former; and the produce, as it is brought from the field, to the creditor side. This produce is then, in its turn, carried to the debtor side of the provision account, the creditor side of which contains the use which has been made of the produce for various purposes. When, however, certain products are consumed as soon as they are taken out of the field—as, for example, clover and vetches given to cattle as green food, and a portion of the radishes—they are immediately charged to the credit of the field, and to the debt of the cattle by which they are consumed. The pecuniary value in this case is, indeed, rather uncertain; but I estimate it according to an approximate valuation of what the produce in question has cost me: some persons may, perhaps, think it better to estimate its value according to the utility and employment of the produce. In my opinion, the former of these two methods is far more advantageous than the latter, at least so far as the greater part of the agricultural establishments are concerned.

The live and dead stock are valued at the termination of each yearly account; a new inventory is then made of them, or the requisite alterations are made in

that of the preceding year. The value of the stock at this period is entered in the following year under the proper heads. Thus, every improvement in the stock during a year is placed to the credit side of that year's accounts; while all the deteriorations, on the contrary, are charged to the debtor side. The account of live stock is debited with the price of whatever cattle have been purchased, and the cash account is credited with it, if the price has been paid in money; while the value of the cattle sold, or the sum obtained for them, is charged to the debtor side of the cash account, and the credit side of the live stock. When a beast dies, the value is debited to the account of the kind of cattle to which it belongs: as, for example, if it be a cow, the loss is added to the debtor account of the cow-house; and if it be a horse, the team account is charged with its loss. This is one of the parts with which beginners are most puzzled and staggered: it appears absurd to them to credit the live stock with the loss of all the cattle which die; and, indeed, the loss is productive of detriment to that stock, inasmuch as the value of it at the end of the year will be proportionably diminished. In this case, as in all others, it is only necessary that a person form a clear and just idea of this method of book-keeping, and he will easily be enabled to extricate himself from these difficulties, and others of a similar nature. The expression "Dr.," at the head of the debtor side of the account, is synonymous with "*have received*," or, "*have benefited by;*" the expression "Cr.," on the opposite side, is equivalent to "*given away*," or "*has furnished.*"

At the settling of the accounts, the sum total of all the items on the *debtor* side ought to be equal to the sum total of all those on the *creditor* side. But the debits and credits of the greater number of the accounts are very different; this is likewise the case with those which have nothing on the debtor, or nothing on the creditor side. The overplus of debt or credit in an account—or, in other words, the sum which must be added to one side in order to make it equal to the other, is called, in commercial language, the *balance*. It may also be termed *profit* or *loss*, *plus* or *minus*. If, then, the profit of all those accounts which have yielded any, be placed on one side, and the loss of all those which have sustained any on the other, the sum of these two accounts ought to be the same. But in order to ascertain the real return or profit of the undertaking during a year, it is necessary, in the first place, to add to the *general debit* of the account the loss on all those accounts which were necessary to carrying on the system of operations, or, what comes to the same thing, the expenses of the establishment; and, secondly, the credit of the preceding year.

On the other hand, the proprietor's debt, or the amount of that which he has drawn from the estate, whether in money or in kind; secondly, the debt of expenses attendant on improvements; thirdly, that of the following year; and fourthly and lastly, the debt of casualties and accidents which must be borne, not by the undertaking, or, what comes to the same thing, by the farmer—supposing the estate is farmed out—but by the estate itself, or by the proprietor (and, therefore, a special account should be kept open for the insertion of these casualties) —all these items must be added to the credit side of the account which is about to be balanced. The residue which is left, after one account has been deducted from the other, is the true net profit or loss.

I should advise all those who may wish to adopt this method of book-keeping, to make trial of it for one year at first, and, during that period, to continue using the method to which they were previously accustomed, in order that their accounts may not be embarrassed and spoiled by errors which might not perhaps at first be discovered.

Whoever has once adopted this method, and entered fully into the spirit of it, will never afterwards give it up, or regret the trouble which it may have occasioned to him at first. The clear, precise, and accurate manner in which it demonstrates every result, not only of each particular part or operation of the rural economy, but also of the relations which the several parts bear to each other; the hints which may be derived from it for the improvement of the system of management and cultivation; the facility which it affords, and with which it enables any one to retain an absolute control over the agricultural operations and the consumption of food, even while in his own chamber, or while absent; and lastly, the indications which it gives of the various objects to which attention ought to be directed—all these will tend abundantly to compensate for the care

which will be required in order to reduce it perfectly to practice, and particularly in the first year. During that period, the most difficult and, nevertheless, the most necessary part of the system, is to establish the day-books, and keep them in a proper manner; but here, also, the difficulty lies, not in the thing itself, but only in the ideas and principles which must be imparted to those persons to whom the keeping of the books is entrusted.*

PROPORTION OF THE MANURE TO THE QUANTITY OF FODDER AND THE NUMBER OF CATTLE.†

The principal article which contributes most to the formation of the plants which we cultivate, which causes them to grow and to bear the seed which is destined for their reproduction, is manure, or the mould produced by its decomposition.

The quantity and quality of the plants which we propagate depends, therefore, on the quantity and richness of the manure which we can afford them. Next, then, to labor and the manner of superintending its execution, the subjects which most naturally present themselves to our consideration are, the nature of manures, the means of obtaining them, and the proportion between the quantity of the manure and that of the produce.

Attempts have been made to supply the place of manure by an increase of labor, or to supply the place of labor by an additional quantity of manure, but the success of these experiments has necessarily been merely apparent at first, and but of short duration. Jethro Tull imagined that he could altogether dispense with manure and replace it by the application of frequently repeated tillage applied to his crops, sown in rows, and by the complete division of the parts of the soil produced by that means. The plan, at first, turned out favorably for himself and his followers, for they had a fertile soil to work upon, which had for a long time previously been plentifully supplied with manure; in fact, by repeated tillage and the consequent exposure of the soil to the action of the air, all the nutritive particles contained in it were converted into extractive matter fit for the food of plants, and thus brought into the service of the roots and their fibres. But this effect can only last for a few years; and wherever this system of drawing upon the riches of the soil is closely followed, it will eventually render it so poor, that plentiful and repeated manurings will scarcely be able to restore it to anything like fertility.

There certainly are some kinds of land which are naturally so rich in themselves, and which have been so little impoverished by cultivation, that they do not require manure; but these are rarely to be met with, and form exceptions to the general rule; we shall treat of them more at length in the proper place. It very frequently happens that the degree of fertility possessed by any particular field or piece of land, and which is entirely owing to the land having been used as meadow ground for some time, and from a number of cattle having been kept upon it, is attributed to the nature of the soil.

* The author has given a lengthened description of the systems that are adopted in keeping accounts in agricultural establishments, a subject that has obtained much attention in this country, and in which considerable difficulty has been experienced when attempted to be followed out to the extent of which it would seem to be capable. The system finally recommended by the author differs little from the most approved method in this country, in which every chief article and operation on a farm is entered in a separate account; that is, every article and operation that influences the conduct of the establishment, and the final loss or gain, and which it is necessary to exhibit in a separate form and disjoined from other contingencies. The result of each separate account appears in a money column, to which standard all values are reduced; and the balance of this column shows the profit or loss in the speculation.

The difficulty lies in determining the number of separate accounts, and in limiting the unnecessary multiplication of books. Some speculative writers have carried their ideas very far, and have proposed separate accounts for each field; but they involved themselves in valuations very difficult to be ascertained, and in calculations not required for the purpose in view. One book, called a "ledger," may comprehend each separate account in columns, and to which book all the other detached accounts will be carried. The number of the latter will depend on the nature and extent of the establishment: labor-books are indispensable, and beyond these two divisions, few concerns will require any more. A separate cash-book is now much used, containing every particular of the sums of money expended, and by which is seen the general state of receipts and expenditure of the whole business, without the trouble of referring to each separate head in the ledger. Many plans and books are proposed to be kept by amateurs, which are not required by the practical man; but every person who knows his business, and thinks on what he is required to do, will, as the author very judiciously observes, form a plan to suit the situation and circumstances, and for which purpose a careful study and examination of every plan published will afford materials of selection, as no single method can be devised which will be adapted to every circumstance of cultivation and locality.

† In order to enter more fully into the views of the author, and, at his request, I have remodeled this chapter, so as to insert in it those observations and those modifications which were originally inserted in the beginning of the second volume of the German edition. [*French Trans.*

Although nature furnishes a number of substances which tend to quicken vegetation, either by augmenting the vital principles or by assisting in the decomposition of the mould, it is only the mould or *humus* (finely-divided organic matter) which is capable of the requisite degree of decomposition, or the vegeto-animal manures, which supply to plants the most essential particles, and those most necessary for their nourishment. I say their most essential particles, because they could likewise derive some nourishment from the decomposition of water as well as from the gaseous substances contained in the air, and from their combination; and that, if instead of removing the plants from the spot on which they grow, they were suffered to remain there and decompose and resolve themselves into earth, the operation of these principles would tend to increase and multiply the mass of vegetable products over the surface of the earth, or of any particular field. This fact appears to be demonstrated by the astonishing fertility of those soils which have never been cultivated, as, for instance, those of ancient forests.

With regard to that portion of the earth which cannot be decomposed, and which resists the action of fire, the experiments made by De Saussure and Schrader tend to prove that it has little to do with the positive act of vegetation, and only contributes to it by receiving the roots of the plants and preserving their nutritive matter, but is itself incapable of affording them sufficient nourishment for their support.

But as plants derive the substance necessary for their nourishment from the *humus*, or decomposing animal and vegetable matter, it of course follows that this matter must be diminished, and, in course of time, exhausted by the vegetation of plants in the soil; and the rapidity and degree of this diminution and exhaustion will be in proportion to the nutrition which these plants absorb, or, what amounts to the same thing, in proportion to the nutrition which they contain; supposing, however, that they are gathered and taken off the ground.

The strength of the vegetation and the quantity of each product is determined by the proportion of nutritive juices or succulent properties contained in the soil. By the terms "nutritive juices" or "succulent properties," we mean to designate that portion of the mould which is in a fitting state to be taken up by the roots of the plants, that which constitutes the richness and is the chief cause of the fertility of the soil; and we admit that the quantity of these juices is modified, augmented, or diminished by each product which is taken from the soil, because every crop we take from the field serves more or less to exhaust the fertility of the soil, and, unless we return it some equivalent in the form of manure, it will very soon become a barren waste.

The degree in which these nutritive juices are absorbed or diminished, is in proportion to the size, weight, and also to the nature of the produce. With regard to the whole class of cereals, both general experience and individual experiments tend to prove that the diminution is in direct proportion to the nutritive substances which these plants themselves, and particularly their grain, contain.

It is well known that wheat absorbs them and exhausts the land much sooner than rye, that rye exhausts it much sooner than barley, and barley much sooner than oats. Experiments commenced by many persons, and which are, in fact, hardly yet completed, demonstrate the existence of this proportion more clearly than could have been expected.

According to be best analysis that Einhof has formed of the different quantities of nourishing and succulent properties, as, for instance, gluten, starch, and mucilaginous sugar, contained in each kind of grain, there appears to be the following proportion:—

In Wheat,	78	per cent.
Rye,	70	"
Barley, according to the qualities and species,	65 to 70	"
Oats,	58	"
but the analysis of this kind of grain is not yet completed.		
Lentils,	74	"
Peas,	75½	"
French Beans,	85	"
Windsor Beans,	68½	"
Horse Beans,	73	"

Thus, a bushel of Wheat of	92 lbs.	contains	71·76	of nutritive juices.
" Rye	86	" "	60·2	"
" Barley	72	" "	48·6	"
" Oats	52	" "	30·16	"
" Peas	100	" "	75·5	"
" Horse Beans	103	" "	75·19	"

From these data, and by taking into account the differences in the nature of the succulent properties themselves, as well as in the straw and in the whole of the experiments relative to this matter, into which, however, we shall not enter until we come to treat of each product separately, we will admit that the crops of grain, properly speaking, bear the following proportions to each other as regards their nutritive principles and the degree in which they exhaust the soil:—

Wheat	13
Rye	10
Barley	7
Oats	5

Thus, 6 bushels of Rye are equal to 4·61 of Wheat.
" " " 8·58 of Barley.
" " " 12· of Oats.

We ought, therefore, to expect that, when a certain quantity of nutritive matter is spread over a soil which, from its composition and physical qualities, is equally fitted to produce any one of the cereal plants, a crop of grain equal to this proportion will be produced; especially if, besides, we can ensure the existence of this equality united with cultivation and the temperature best adapted to the kind of grain that is used. This proportion generally exists in the crop; for, if at one time we obtain a more plentiful return than was expected, the following harvests will be proportionally diminished.

The relation of the produce to the exhausting property, has not, as yet, been determined with any degree of precision, excepting in those kinds of grain in most common use. As to other vegetable products, we do not, as yet, know any thing definite respecting them; the results are doubtless very different where these crops occur very frequently, instead of being used as intermediate or alternate products with separate crops of the gramineous grain-bearing plants. We shall not enlarge on this subject, until we come to speak of the succession of crops, and shall only observe here, that vegetables, peas, beans, and vetches have been regarded as ameliorating crops; and their possessing this property has been attributed to the shade which their leaves produce, the kind of culture they require while growing, which loosens the soil and keeps it clear of weeds, the air which they exhale, and the stem and large roots which they leave in the soil. Many persons have considered these crops as equivalent to a dead fallow, when they are not repeated too frequently in the same place, and when the plants are both vigorous and close together, which can only happen where the land is in good condition. Experience and theory, however tend to prove that it is going rather too far to compare these crops to a dead fallow, which latter really causes an actual increase in the nutritive portion of the soil. The number of experiments on this subject which have been made on land cultivated according to the triennial rotation of crops, has induced a great number of agriculturists to think that, supposing the quantity of manure and the number of plowings to be the same in both cases, the crop of autumnal corn and the spring crop by which it is succeeded will be about a bushel less in quantity than they would have been after a dead fallow. But ten degrees less of fertility will not explain this deficiency; it will require rather from seventeen to twenty degrees, for the rye will absorb five out of the seventeen, before it can produce a bushel of grain; consequently, if the fertility of the soil is diminished from seventeen to twenty degrees, the produce in rye will also be diminished by a bushel, and the spring crop will be reduced in proportion to the twelve or fifteen degrees which still remain to be used. For this reason I fix the positive exhaustion, or impoverishment occasioned by crops of vegetables, at ten degrees, and take that as a general average, without pausing to inquire whether the crop is plentiful or not; because experience teaches us that the finer the vegetation, the less does it impoverish the soil. Some attentive observers have remarked, that when the winter crop of corn was

very fine and abundant after peas, the spring crop was proportionably poor; in these cases, therefore, they sowed oats instead of barley. Superficial observations have rendered the opinions exceedingly diversified with regard to the greater or less exhausting properties of other products. Many agriculturists assert, that potatoes deteriorate and exhaust the productive power of the soil very much; and adduce in support of this opinion the ill-success of the autumnal crop of corn which succeeds the potato crop; this assertion, however, generally emanates from those who sow their seed immediately afterwards, without any previous preparation, or without the interposition of any ameliorating crops—as turnips, or grass—and, consequently, when the land is in an unfavorable condition for the reception of grain. On the other hand, we meet with persons who cultivate the spring crop after potatoes, and are ready to maintain that it yields equally as well as the autumnal crops which succeed a fallow. It has been lately proved by several experiments, that potatoes, and other roots cultivated successfully, exhaust those soils which were previously in good condition but little. This, however, seems to me to be carrying the matter too far: my own observations have led me to believe that two loads of manure per acre, each containing twenty quintals, will more than equal the impoverishment occasioned by a crop of potatoes; at least, wherever I have allowed this quantity, I have never been able to detect any diminution in the two crops of grain, viz. rye and barley, which followed. I must entreat all persons who have the opportunity, to pay attention to this subject. Here, again, there ought to be some difference made between the treatment of the soil after a plentiful crop, or after one which is not so abundant. If the potatoes are planted very closely together, they certainly produce a greater quantity; but then they cannot be so carefully cultivated; the fertilizing influence of the cultivation is, consequently, very considerably diminished, and the soil is more impoverished. I am, therefore, content with 80 bushels of produce, for the small quantity of five bushels of seed, per acre. Thus, I reckon the exhaustion which they occasion at thirty; attributing to them, on the other hand, the same fertilizing influence as that of a fallow, namely, ten degrees.*

The exhaustion or impoverishment occasioned by crops of grain may be repaired in three ways:—

In the first place, by the carrying and incorporation of manure, properly so called. The nutritive faculty of the soil is more or less augmented in proportion to the quality of this manure; and the goodness of the crop is also regulated by the same power, at least to a certain point; but beyond that, the manure becomes absolutely injurious, causing over luxuriant growth of corn. In forming an estimate of the amelioration or deterioration of the soil, we may regard a load of dung, taken at a suitable degree of fermentation, and weighing 2,000 lbs. as equal to ten degrees on an acre of land; and thus, five such loads of manure would be equal to fifty degrees.

The nature of the manure must likewise be taken into consideration; we have here supposed it to be common manure, composed of the excrements of cattle, or of horses and pigs, and combined with straw or litter. The dung of sheep, especially that distributed over the fields by the pasturing of these animals on them, is not equally efficacious; it becomes more rapidly the food of plants, but it is also more quickly exhausted.†

* The author, from experience, recommends the application of a small quantity of dung on land that has produced a crop of potatoes, in order to correct the (supposed ?) deterioration inflicted on the soil by that plant. Though he has applied dung on the supposition that the crop unduly exhausts the soil, he seems in doubt if the exhaustion be real or imaginary, and advises further attention to the subject. A long and very extensive individual experience, in which potatoes and turnips were cultivated on a great variety of soils, loamy clays, sands, and gravels, in the same field, and with the same management in every respect, never, in any one instance, showed the least visible difference on any succeeding crop—wheat, barley, oats, or grass seeds; on the contrary, it is thought that all the crops, especially the last mentioned, thrive best on potato tilth, from the greater degree of pulverization which the land receives. Belief can hardly be given to the assertion, that a green crop, whose soil is manured, cleaned, and pulverized, can exhaust land more than two or three grain crops in succession; the current opinion must have arisen from attributing the effect to the wrong cause, and that opinion seems to have misled the author so far as to induce the application of an additional quantity of manure, without sufficient reason for such an application.

† Experience will receive with limitation this observation of the author, that land is exhausted by heavy crops of esculent plants, and that it is enriched by thin slight crops from admitting more perfect cultivation. General observation would lead to a contrary conclusion in this country; in the case of thin straggling crops of any kind, the benefit imparted by the shade of close crops is wholly wanting, and exposure would seem to be detrimental. The quantity of seed allowed by the author to an acre of potato ground is only five bushels; the produce is sixteen from one, which is about an average crop in this kingdom.

Secondly, by what is called repose, or inactivity (*repos*), or, rather, by the conversion of the fields into pasture grounds. The putrefaction of the herbage which grows spontaneously, of the worms and insects that lodge in it, and the excrements of the cattle which pasture on it, communicate to the soil a nutritive power, which is greater or less in proportion to the state of the land when it was left to nature, to the abundance and vigor of the vegetation, and to the quantity of excrements voided by the cattle.*

This advantage may be fixed:

(*a*) According to an inverse proportion of the extent necessary for the whole maintenance of a cow.

If 3⅓ acres be sufficient,	this amelioration	may be	considered	as equal to	10	degrees.
If 3	"	"	"	"	11	"
If 2⅔	"	"	"	"	12	"
If 2⅓	"	"	"	"	13	"
If 2	"	"	"	"	14	"

On the other hand, if 3⅔ acres are required for a cow, the amelioration can only		be considered as equal to	8
"	if 4	"	6
"	if 4⅓	"	4

(*b*) Or according to the state of fertility in which the soil was allowed to grow herbage.

If the soil contained	40	degrees of fertility,	then it annually gains	10	degrees.
"	50	"	"	11	"
"	60	"	"	12	"
"	70	"	"	13	"
"	80	"	"	14	"
"	90	"	"	15	"
If, on the contrary, only	30	"	"	8	"
"	20	"	"	6	"
"	10	"	"	4	"

When we come to treat more particularly of herbage, we shall enter more fully into an explanation of the method of determining the value of the pasturage, according to the degree of fertility contained in the soil.

The additional fertility which is produced by clover, varies according to the closeness of the crop, and the length of shoot which the plants are suffered to attain before they are buried by plowing; and this latter circumstance has a very material influence on the improvement produced by clover. In fact, it is evident that when this plant is thick and averages from eight to nine inches in hight, it yields a very considerable proportion of vegetable manure to the soil; but the thicker the clover, the greater will be this advantage, because then one plowing will be sufficient. It may be laid down as a general principle, that clover sown on land containing 60 degrees of fertility, will improve it by 10 degrees; if the land contains 70 degrees, the improvement will amount to 12 degrees; if 80, to 14; and if 90, to 16, &c. &c.

The same may be observed with regard to vetches cut while green, if before burying them, they are allowed to stand and sprout again; but this second growth can only take place where the plants are thick and vigorous, and where they were mown just as they had begun to flower.

Thirdly, by a dead summer fallow, attended with proper cultivation; by means of which the soil will not only be cleaned and pulverized, but will likewise receive positive nutrition, as well from its different parts being successively submitted to the fertilizing influence of the gases contained in the atmospheric air, as from the putrefaction of the plants and roots buried in it by the operation of plowing being hastened and expedited. The more vigorous and better the soil, the more efficacious does the fallow become; and in proportion as it has been complete, and the soil has been thoroughly cleaned, pulverized, and aerated, and the nutritive particles which it contained brought into action, will the subsequent crops be abundant. It is, however, a fact that in this manner a greater degree of exhaustion is subsequently created.

* The crops of the farmer, if used in their green or unripe state, exhaust the soil which produced them in a much less degree than the same crops when suffered to ripen their seed; for their saline, and other matters, increase in proportion as the plants attain maturity. Now, the ameliorating grass lands to which our excellent author alludes are those fed incessantly by the live stock of the farm; the produce consumed green; the soil constantly enriched by the excrements of the cattle by which they are deposited.

There is no doubt that the fallow absorbs or attracts the fertilizing properties of the atmosphere, and that the better the condition of the soil the greater is the quantity of nutritive particles thus absorbed; besides, the richer the soil the greater will be the quantity of weeds which spring from it, and the putrefaction of which will also contribute to ameliorate it. From these considerations we may conclude, that if the soil contains 40 degrees of fertility, the fallow will add 10 to it; if 50, the increase will amount to 11; if 60, to 12, and so on.

Every one must determine for himself, according to his own situation and circumstances, which of these three methods of improving the land will suit him best. Should he have succeeded in being able to procure an abundant quantity of manure from his own farm, he will, doubtless, find the first mentioned mode to be the most efficacious; but, unless that be the case, the other two may be advantageously adopted.

A field is seldom so much exhausted by the crops which it has successively produced as to be incapable of yielding any further produce. It may, however, be so much impoverished that the value of the crop will barely cover the expenses of cultivation. This faculty of production inherent in the soil is designated the natural fertility. There are different degrees of this fertility; when it is so high that an acre of land may still be made to yield two bushels of rye more than the quantity sown, and nevertheless must not be sown again from fear of exhausting it too much, until it has been manured or suffered to rest, or be fallowed, then its natural fertility is supposed to be equal to 40 degrees; and this is the greatest extent of exhaustion which a piece of land of average quality, should ever be suffered to reach. Good barley land which does not contain more than sixty parts in a hundred of sand, a small quantity of lime, and perhaps about two parts in a hundred of finely-divided organic matter, will seldom become so much impoverished, unless, indeed, it be purposely exhausted. When it has been manured once in six years, we always attribute to it 60 degrees of fertility, even though it may have produced four crops of grain; and we may then, if we choose yet further to exhaust it, also obtain other crops, care being used to choose those which will only require nutrition in proportion to this number of degrees. It is generally supposed that the more favorable the constituent parts of the soil to the reproduction of vegetation, the greater will this *natural fertility* be; and that, in proportion as the soil is of an argillaceous nature, it will be more difficult for it to be impoverished to that extent which we have here designated by 40 degrees, and, for the reason that it retains the nutritive juices longer, will produce less returns to cultivation, while it possesses within itself a richness which only requires to be brought into action by thoroughly dividing the integral parts which contain the nutritive and succulent matter. It requires a great deal of art thoroughly to exhaust land of this nature; but, when once it is done, an immense sum must be expended before it can be restored to a proper degree of fertility.

This property of the soil which we term its *natural fertility*, because it is innate, and possessed by the soil at the time we bestow fresh nutritive matter on it, and particularly when we recommence the rotation or succession of crops, and forms the ground-work of the amelioration which we wish to produce—this fertility, I say, is increased or diminished according to the quantity of manure which is mixed in the land, and the number and kind of crops which are produced during the course of the rotation.

Thus, if a field has received five loads of manure, each containing 20 quintals, for this must be allowed	50 degrees.
For a dead fallow	10
For its natural fertility	40
Thus, the whole amount of richness and nutrition may be valued at	100 degrees.

Others endeavor to attain the same end by means of trenching with the spade, acting on the belief that the under layer of the soil acquires additional fertility while it lies buried and inactive, and that when brought to the surface it will bear abundant crops; and they fancy that by changing the layer of the earth every year they shall ensure good crops, without being obliged to replenish the land with nutritive matter.

It certainly does occasionally happen that on some soils, where the layer which

is turned up and brought to the surface is composed of a mixture of substances which contain combinations of oxygen and hydrogen susceptible of decomposition, this system appears to be successful for a time; but it will not endure for any length of cultivation, for after having produced a few crops without being manured, the land becomes so poor as to be incapable of affording the smallest nourishment to plants.*

In the neighborhood of large towns, where manure can be obtained at a low price, and in countries where, on account of the great extent of pasture lands, a large number of cattle are kept, little labor is bestowed on the ground; it is never suffered to lie fallow; the proper rotation of crops is not observed; the fields are sown with grain every year, and frequently with the same kind of plants. In those places, on the other hand, where, from want of fodder, a small quantity of dung can be obtained, the farmers seek to improve their lands by constant plowing and cultivation, and particularly by allowing them to lie fallow, and either converting them into pasture grounds or leaving them perfectly inactive. This circumstance constitutes the great difference between the systems of cultivation pursued in Holstein and Mecklenberg, which are otherwise so similar. In the former country they manure the land very plentifully, and, in order to accomplish that purpose, they devote a considerable portion of it to the growth of plants destined for the maintenance of cattle; but they plow the fields very little, even for the reception of grain. In Mecklenberg, on the contrary, where the system of cultivation will not admit so much manure being expended on the land, the want of it is supplied by frequent, carefully managed, and complete fallows. Although this substitution may be practicable to a great extent, similar results must never be expected from it, since the greatest portion of produce can only be obtained when the soil, the manure, the labor, and the kind of grain sown, are in their relative proportions to each other.

And if we deduct from this sum the value of the impoverishment occasioned by the crops produced in the course of the rotation, the balance which remains will indicate the *natural fertility* of the soil at the close of the succession or rotation, or that number of degrees with which the ensuing course will commence. There can be no doubt that there is a certain regularity and proportion existing in the exhaustion occasioned by the crops. It is thus that, after a fine crop of autumnal corn, the spring crop generally proves meagre and scanty; and that, in the triennial rotation with fallowing, the autumnal crop in the second year, after a remarkably good crop of spring corn, will not be found to answer so well.† For the same reason, we see that a succession of abundant and scanty crops, the former having been favored by weather and temperature, flourish and yield plentifully, but impoverish the soil very considerably; while the latter, having been retarded by unfavorable weather, leave more nutritive matter in the soil in which they vegetated than they originally derived from it. A careful examination and observation of this law of nature may lead to results which will enable us to obtain plentiful crops precisely at those seasons and in those years when, in the ordinary course of things, we should have obtained very bad ones; it may also teach us to reserve those powers which will overcome even the influence of unfavorable temperature for using in the latter periods. By this means, a generally bad year may be rendered exceedingly profitable by a skillful and scientific agriculturist. It is, therefore, evident that the fact of the same system of cultivation not being every where established and practised, is really a public benefit.

Until other, more numerous, and better authenticated experiments have been made, and all the light thrown on this subject of which it is susceptible, we are

* The author thinks much art will be required in exhausting a certain kind of land, and very judiciously adds, that much more art, and also expense, will be required in repairing the damage after the exhaustion has been effected. In this country the art of exhausting lands is reckoned very simple, viz., by continued cropping, which will effect the purpose in a greater or less time according to the degree of natural fertility. The art of restoring fertility to lands is naturally more difficult. and much aggravated by the expense, which mightily increases the difficulty of the art. though the process be universally known. No farmer, who deserves the name, will ever allow such a result to happen on lands that are under his charge.

† The observation here made by the author, that a good crop of spring corn seldom succeeds an abundant autumnal crop, and *vice versa*, is in exact accordance with the established fact that two grain crops should not follow each other. The following remark, that a bad crop of any kind enriches the land by not extracting so much nutritious matter as an abundant produce, is more difficult of admission in this country; and the meaning of the author is rather obscure how the skillful agriculturist can render a bad year profitable, and secure plentiful crops in adverse seasons, by any previous foresight or arrangement.

led, from what is at present known, to believe that a crop of wheat will impoverish a fertile and not too cold a soil in 40 degrees; while a crop of barley will only exhaust 30 degrees, and a crop of spring grain 25 degrees.

When wheat is sown on a soil fitted for its reception, it frequently yields as large a quantity of grain as rye; and the produce not only weighs more, but also contains a greater amount of nutritive matter in the proportion of 13 to 10; thus, the proportion which exists between the degrees in which these two kinds of grain exhaust the soil, ought to be as 39 to 30; but as the impoverishment occasioned by wheat appears to be still greater, we will therefore suppose it to be equal to 40. With regard to the spring crops of grain, the short time their vegetation lasts must be a sufficient proof that the exhaustion which they occasion is much less; and, indeed, it is seldom that they yield in produce an equal quantity of nutritive matter with that furnished by the autumnal crops. For some time past, opinions have been divided in the question whether barley or oats are most exhausting; and the answer, doubtless, depends upon the state of the soil, the preparation which it has received, and the abundance of the crops of either kind which it has produced. On strong land which has received a slight plowing, oats, which possess a greater capability of absorption, will exhaust more than barley; but then they will also produce a finer crop, and we therefore consider them to be about equal.

These data are not founded merely on the theory of the nutritive or succulent matters, but are deduced from a summary of the results furnished by general experience, and are in perfect harmony with those which have been observed in well directed agricultural undertakings, and which in average years are admitted in case of lands of moderate fertility. We only summon theory to our aid in this case to assist us in forming a standard or measure by means of which each product may receive an average value, always taking into account the various circumstances by which it is influenced; and the realization of this standard or measure proves, in its turn, the correctness of the theory.

Some of the more exhausting kinds of grain may occasionally, under the influence of favorable weather and temperature, yield a larger amount of produce than we have here assigned to them; but they will also impoverish the soil in a greater degree, and the succeeding crops will be proportionally less. All that is here attempted is to discover the sum total of the produce, and the greater or less degree of fertility retained by the soil.

In this hypothetical calculation I have endeavored, as much as possible, to confine myself to round numbers, and to leave out all fractions; because these latter would only have rendered the calculations more difficult, without making any sensible difference in the results.

If we would calculate the probable produce of a crop of any single species of grain, according to the amount of easily soluble matter in the soil, we must take several accessory circumstances into account. When these accessory circumstances are favorable, a vegetable will yield a much larger produce from land possessing the same nature and degree of fertility than when the contrary is the case. These circumstances include a cultivation or preparatory crop which will destroy all the weeds which would otherwise prove injurious to the produce, and also those influences of the weather which we can neither foresee nor prevent. We ought, therefore, to have these circumstances constantly before our eyes while endeavoring to form an estimate of the produce, which, from the fertility of the soil and the nature of the grain, we may be led to expect; and to bear in mind that this attractive power can only be brought fully into action where it meets with no obstacles.

We have stated the average absorbing power of rye to be as 30 to every 100 degrees of soluble or succulent matter in the soil, and we shall now fix the produce of this kind of grain at six bushels besides the seed; thus allowing five degrees of impoverishment for every bushel.

According to the same principle, and to the proportion of the absorption of nutriment of the different kinds of grain, we ought to attribute

To a bushel of wheat, 6¼ deg. of impoverishment.
" barley, 3¾ "
" oats, 2¾ "

and, consequently, to be able to calculate the probable number of bushels which

will be yielded by a crop of each kind of grain on land of a certain degree of fertility, as well as the impoverishment of the soil which will ensue. In fact, we ought to be able to distinguish the exhaustive power possessed by a particular kind of grain, from the nutritious juices of the soil which it employs in its formation; for these two things do not always seem to be in absolute relation to each other. But the quantity of nutritious matter which a bushel of grain employs in its formation, is equal to the quantity which this measure detracts from the soil.

In order to explain what we have already said with regard to the proportion in which different kinds of grain exhaust the soil, we will give a few examples; and suppose, in the first place, that the soil contains 140 degrees of fertility. The exhausting power of wheat is 40 in 100.

100 : 40 : : 140 = 56.
A bushel of wheat absorbs 6½ degrees of fertility,
6·5 : 1 : : 56 = 8·6 bushels, which may be produced by these 140 degrees of fertility.
The exhausting power of rye is 30 in 100.
100 : 30 : : 140 = 42.
A bushel of rye absorbs 5 degrees of fertility,
5 : 1 : : 42 = 8·4.
The exhausting power of barley is 25 in 100.
100 : 25 : : 140 = 35.
A bushel of barley absorbs 3½ degrees of fertility,
3·5 : 1 : : 35 = 10.
The exhausting power of oats is 25 in 100.
All these quantities are exclusive of the seed sown.
100 : 25 : : 140 = 35.
A bushel of oats absorbs 2½ degrees of fertility,
2·5 : 1 : : 35 = 14.

Or, if the produce be known, and it is only requisite to obtain the quantity of nutritive matter which has been absorbed, we proceed in an inverse method.—We will suppose 8 bushels of wheat, besides the seed: 1 bushel requires 6½ degrees of nutritive matter; therefore 52 degrees have been absorbed, and there only remains 88 of the 140.

If we suppose 8 bushels of rye, each bushel absorbing 5 degrees; these 8 will deduct 40 degrees from the 140, and only 100 will remain. Again, if we suppose 11 bushels of barley, at 3½ degrees, per bushel, these 11 will impoverish the soil 38·5 degrees, and there will only remain 101·5. And, lastly, if we suppose 14 bushels of oats, at 2½ degrees per bushel, this quantity will exhaust 35 degrees of the fertility of the soil, and leave 105. It depends upon circumstances, some of which are within our control and the others beyond its influence, whether the number of bushels thus reckoned from a calculation of the fertility of the soil and the exhausting properties of the grain will be realized, or whether the sum will be augmented; but, be the produce what it may, the impoverishment of the soil will be proportionate to the number of bushels of grain obtained.

As every thing relative to the doctrine which I am here laying down appears to me to be of sufficient importance to merit such a clear and precise explanation, as will help to obviate all possibility of misconception, I shall subjoin, as examples, some calculations relative to the augmentation, or diminution of fertility which is produced by the various rotations of crops.

If the natural fertility of a soil be	40 degrees.
And to this is added five loads of manure	50* "
	90 degrees.

And then, without being again manured, it is subjected to the triennial rotation with naked fallowing: it will present the following results.

In these calculations, I have intentionally deducted the quantity of seed sown from the product; therefore, if any one should wish to ascertain the sum total of produce, he must add the amount of the seed to the quantity here given. It is certainly probable that the seed contains a quantity of soluble matter, quite sufficient for a single reproduction; and that thus the increase of the quantity of seed, at least to a certain extent, always gives a much greater gross amount, although it does not yield any considerable increase of net produce.

* A load of manure is here supposed to contain twenty quintals.—*French Trans.*—A quintal is equal to 112 lbs. English.

Rotation of the Crops.	Produce of the Crop over the Seed.	Succulent matter absorbed in Proportion to the Species and Quantity of the Grain.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Fallow year........ ..	..	..	10	100
2. Rye*............	6	30	..	70
3. Barley*..........	5	17·5	..	52·5
4. Fallow†...............	..	..	11	63·5
5. Rye............	3·81	19·05	..	44·45
6. Oats‡.................	4·44	11·11	..	33·34
7. Fallow................	..	..	10	43·34
8. Rye...............	2·6	13	..	30·34
9. Oats..................	3·03	7·58	..	22·76

Thus we see that the natural fertility of the soil, which, at first, was 40 degrees, has diminished to 22·76; consequently, it has lost 17·24; and this is the invariable result of that system of cultivation which, after an amelioration of five loads of manure per acre, exacts six crops of grain. In order to avoid this great exhaustion of the land, the rotation should have been interrupted after the fifth crop; but, by means of feeding cattle on the ground, it might have been made to bear the sixth crop, and, beyond this point, no person should ever go without manuring the land afresh.

Should it be thought desirable to sow peas on the manured fallow in this rotation of crops—without, however, bestowing any additional quantity of manure—the peas will, as we have already observed, return some portion of the nourishment absorbed from the soil, but without producing the effect of a naked fallow. In this case the following will be the results:—

Rotation of the Crops.	Produce of the Crop.	Nutritive Matter absorbed in Proportion to the Species and Quantity of the Grain.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Peas............	5	20	10	80
2. Rye............	4·8	24	..	56
3. Barley...............	4	14	..	42
4. Fallow...............	..	..	10	52
5. Rye............	3·12	15·6	..	36·4
6. Oats..................	3·64	9·1	..	27·3
7. Fallow...............	..	..	16	37·3
8. Rye......	2·23	11·9	..	26·11
9. Oats............	2·6	6·52	..	19·59

Here the soil has lost 20·41 degrees of the fertility which it previously possessed. If without augmenting the quantity of manure in this rotation, the farmer should choose to have a crop of potatoes instead of the first fallow, and if these roots impoverish the soil as much as a crop of rye, and nevertheless from the culture they require, bestow on it all the advantages of a fallow, the following will be the results:—

Rotation of the Crops.	Produce of the Crops.	Nutritive Matter absorbed in Proportion to the Produce.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Potatoes...............	80	30	10	70
2. Barley........	5	17·5	..	52·5
3. Oats..................	5·24	13·12	..	39·38
4. Fallow...............	..	..	10	49·38
5. Rye..........	2·96	14·81	..	34·57
6. Oats..................	3·45	8·64	..	25·93
7. Fallow...............	..	..	10	35·93
8. Rye......	2·15	10·67	..	25·16
9. Oats..................	2·51	6·29	..	18·87

It will here be seen that the soil has lost 21·13 degrees of the original fertility, and it is therefore still left more impoverished. It certainly is not usual to sow barley in the second year of the triennial rotation of crops in the place of rye, but it was necessary to do so here.

This example will tend to prove that the accusation of impoverishing the soil,

* The 25 per cent. of succulent matter left in the soil by the rye crop, 17½ degrees, which, at 3·5 per bushel of barley, ought to produce 5 bushels. [*French Trans.*

† 11, instead of 10, because that the soil has 52 degrees of fertility, instead of the 40 which it possessed at the time of the first fallow. [*French Trans.*

‡ The 25 per cent. of 44·45, that is to say 11·11, which, at 2·5 per bushel, makes 4·44 of oats. [*French Trans.*

so generally brought against potatoes, is not without foundation, since their introduction here not only diminishes the amount of all the crops which succeed them, but likewise increases the exhaustion of the soil.*

Where potatoes are cultivated as food for cattle, and are converted into manure, which is spread over the ground during the first fallowing, the results will be very different. But when potatoes are introduced into the triennial rotation, they are usually cultivated for a very different purpose.

Supposing that at the commencement of a seven years' rotation with pasturage,† the soil possesses of natural fertility	40	degrees.
The usual quantity of manure is bestowed on it, making	50	"
And that it becomes grass land for three years	30	"
	120	degrees.

The following will be the results:—

Rotation of the Crops.	Produce of the Crops.	Nutritive Matter absorbed.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Fallow	..	..	13	133
2. Rye	7·98	39·9	..	93·1
3. Barley	6·64	23·27	..	69.83
4. Oats	6·98	17·45	..	52.38

Here the soil has gained 12·38 additional degrees of fertility, and commences the succeeding course of crops with this advantage.

Nine years' rotation with pasturage:

Natural fertility	40	degrees.
Five loads of manure	50	"
Four years' pasturage	40	"
	130	degrees.

Rotation of the Crops.	Produce of the Crops.	Nutrition absorbed by the Crops.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Fallow	..	..	14	144
2. Rye	8·64	43·2	..	100·8
3. Barley	7·2	25·2	..	75·6
4. Rye	4·53	22·68	..	52·92
5. Oats	5·29	13·23	..	39·69

Here, then, the soil is impoverished 0·31; the increase of produce yielded, is seemingly greater, but not real; this system has, therefore, fallen into disrepute, although once so much approved, and is now almost entirely abandoned.

In the rotation of eleven years with pasturage, the land is rarely manured with the first fallow; it, therefore, commences the course with no resources but the natural fertility, and the amelioration resulting from four years of pasturage, 80 degrees.

The results in this case are as follows:—

Rotation of the Crops.	Produce of the Crops.	Nutrition Absorbed by the Crops.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Fallow on the broken up pasture ground	..	..	14	94
2. Rye	5·64	28·2	..	65·8
3. Oats	6·58	16·45	..	49·35
4. Fallow, with six loads of manure	..	..	71	120·35
5. Rye	7·22	36·1	..	84·25
6. Barley	6·10	21·06	..	63·19
7. Oats	6·31	15·79	..	47·4

* In this tabular rotation and comparative statement, potatoes are shown to exhaust the supposed fertility of the land, and also to diminish the amount of the succeeding grain crops. This last result differs from the previous supposition that light crops left more nutritive matter than good returns; if it has been left in this case, it has been inoperative, though the land was fallowed and might be supposed to call it into action. But the assumption on which the whole calculation rests, viz. that a crop of potatoes exhausts land as much as a crop of rye, is purely hypothetical.

† *Siebenschlä gige Koppelwirthschaft.* In Germany the term "Koppelwirthschaft, signifies a system of cultivation, in which the crops of grain are succeeded or preceded by two or more years of pasturage, as is generally the case throughout Holstein and Mecklenberg.

Here the soil gains 7·4 degrees in eleven years.

Should we attempt to give examples of *complete alternate rotations,* with stall-feeding of cattle*, we must necessarily suppose that the quantity of manure applied to the crops, is far greater than that already specified; but the fertility of the soil always remains the same; in fact, unless it be possible to obtain an additional quantity of manure for the time, it would be folly to attempt introducing such a rotation, because the soil would very speedily be exhausted by the fallow crops.

We will, then, allow that, in a quadrennial rotation of this nature, one ought to commence by bestowing, at least, eight loads of manure per acre on the land during the first year; so that, with the natural fertility, the soil may contain 120 degrees.

Rotation of the Crops.	Produce of the Crops.	Nutrition absorbed by the Crops.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Potatoes..........	80	30	10	100
2. Barley...........	7·14	25	..	75
3. Clover...........	..	..	13	88
4. Rye.............	5·28	26·4	..	61.6
At the second rotation, ten loads of manure may be given......	..	..	100	161·6
1. Potatoes..........	100	37·5	10	134·1
2. Barley...........	9	33.52	..	100·58
3. Clover...........	..	..	18	118·58
4. Rye.............	7·11	35·57	..	83·01

Thus, during these eight years, and in the course of the two rotations, the soil gains 43·01 degrees of fertility.

We will now give an example of some land submitted to an alternate rotation of the same nature, but divided into seven parcels,

The natural fertility of which is..................................	40	degrees.
And to which has been added eight loads of manure..............	80	"
	120	degrees.

Rotation of Crops.	Produce of the Crops.	Nutrition absorbed.	Additional Fertility.	Remaining Fertility.
	Bushels.	Degrees.	Degrees.	Degrees.
1. Potatoes..........	80	30	10	100
2. Barley...........	7	25	..	75
3. Clover...........	..	..	13	88
4. Clover...........	..	..	13	101
5. Rye.............	6·06	30.3	..	70.7
6. Peas, with two loads of manure...	..	20	50	100·7
7. Rye.............	6·04	30·21	..	70·49

The soil has thus gained 38·49 degrees of fertility.

In order to be able more easily to compare the increase of fertility or the impoverishment of the soil, which are the results of these several rotations, we shall reduce the course to ten, and then we shall have the following results:—

Rotations.	Increase of Fertility.	Diminution of Fertility.
Triennial rotation, with dead fallows and an amelioration of five loads of manure in nine years..................	..	17·24
The same, with peas on the first fallow..................	..	22·67
Do. with potatoes on the first fallow..............	..	23·47
The seven years rotation with pasturage..................	17·67	..
Nine years rotation with pasturage......................	..	0·34
Eleven years rotation with pasturage.....................	6·73	..
The alternate four years rotation with stall-feeding........	53.76	..
Seven years rotation with ditto..........................	43.53	..

* *Assolemens alternes* (alternate rotations); it is thus that we designate the systems of cropping, in which one part of the crops is destined for the maintenance of cattle and the other for that of man. Thus, rotations with pasturage are properly called alternate rotations, although the successive crops of grain which are generally introduced are wholly at variance with the principles which ought to form the basis of "complete alternate rotations." [*French Trans.*

To this must be added the progressive increase of the manure, which takes place in all those rotations in which the general fertility is increased; and also the diminution which is daily visible in the manure in all those rotations which tend to decrease the fertility. Thus, the two latter rotations with pasturage, of which we have spoken, and which maintain a kind of equilibrium, may be continued for any length of time with equal success; whereas the others fall off, the former from exhaustion and want of manure, the latter from the excess of it, and require to be submitted, for a time, to some other course, or system of cultivation, which will tend to furnish the necessary supply of manure to the first, or absorb that overplus in the second which the regular rotations were unable to consume.

The triennial rotation of crops, as we have described it, absolutely requires an additional quantity of manure, or that the greater part of the fields shall only be made to produce a crop once in three years, and during the intermediate time shall receive one year's repose and a complete fallow. With regard to the alternate perfectionated rotation, it will be necessary to modify it by substituting vegetables intended for sale, for one part of the plants raised for fodder; because the former, by absorbing the superabundance of manure, will produce the finest and largest crop that can possibly be expected.

The quantity of manure here laid down is certainly only hypothetical, but we shall presently prove it to be that which is requisite for the second rotation. In the triennial rotation with fallows, it will be impossible to bestow a greater quantity of manure on the land than we have here stated, unless the farm contains a good portion of meadow and pasture land, or there are some other means of procuring manure within reach, or, lastly, unless recourse be had to the cultivation of clover, and to the stall-feeding of cattle. The rotations with pasturage may, and frequently will enrich the land much more than we have here calculated: and the same may be observed with regard to the alternate perfectionated rotations, whether united with pasturage or with stall-feeding.

As the system which I am about to mention appears to be, in my opinion, of sufficient importance to merit a clear and concise explanation, which may remove any misconception, I shall add as examples some calculations relative to the augmentation and diminution of fertility consequent on the systems of cultivation pursued in those agricultural undertakings which have been conducted on some of the best cultivated lands of Prussia.

I ought to observe, that in these tables the products in grain have been deduced from the results of actual experience, and not from those rules which I have already given; nevertheless, it will be seen that in general, and upon the whole, they are in tolerable keeping with each other, provided we commence at the second rotation of the course, when the soil has attained that degree of fertility which ought to be produced by this kind of cultivation.

In order to avoid useless fractions, I shall suppose the quantity of seed sown to be only a bushel per acre, and I shall subsequently deduct it from the produce, so as to be able to calculate the impoverishment which may be expected to ensue from the amount of the overplus.

No. 1.—Triennial Rotation System of Fallowing in all its Purity.

		Increase of Fertility.	Decrease of Fertility.
a	Fallow	10 degrees.	— degrees.
	6 7-10 loads (of 20 quintals) of manure	67	—
b	Rye, 6 bushels	—	30
c	Barley, 6 bushels	—	21
d	Fallow	10	—
e	Rye, 3 bushels	—	17·5
f	Oats, 4 bushels	—	10
g	Fallow, with a few cattle or sheep fed upon it	28	—
h	Rye, 4 bushels	—	20
i	Barley, 3 bushels	—	10·5
		115 deg.	109 deg.

The soil would thus gain an increase of 6 degrees of fertility in 9 years, were it not that the manure produced by this rotation is composed chiefly of straw, and consequently inferior in quality.

No. 2.—Perfectionated Triennial Rotation.

		Increase of Fertility.	Decrease of Fertility.
a	6 loads of manure	60 degrees.	— degrees.
	Peas	—	10
b	5 bushels of Rye	—	25
c	Barley, 5 bushels	—	17·5
d	Fallow, with 6 loads of manure and a few cattle fed upon it.	90	—
e	Rye, 7 bushels	—	35
f	Barley, 7 bushels	—	24·5
g	Clover	12	—
h	Rye, 6 bushels	—	30
i	Oats, 7 bushels	—	17·5
		162 deg.	159·5 deg.

Gained in nine years, 2½ degrees.

No. 3.—Septennial Rotation with Pasturage.

		Increase of Fertility.	Decrease of Fertility.
a	Fallow	12 degrees.	— degrees.
	5 8-10 loads of manure	58	—
b	Rye, 7½ bushels	—	37·5
c	Barley, 7½ bushels	—	26·25
d	Oats, 7 bushels	—	17·5
e	Clover for mowing	10	—
f g	Pasturage	20	—
		100 deg.	81·25 deg.

Gained during the seven years, 18¾ degrees of fertility.

No. 4.—Rotation of Ten Years with Pasturage.

		Increase of Fertility.	Decrease of Fertility.
a	Fallow	10 degrees.	— degrees.
	3 loads of manure	30	—
b	Rye, 7 bushels	—	35
c	Oats, 9 bushels	—	22·5
d	Fallow	10	—
	5 loads of manure	50	—
e	Rye, 7 bushels	—	35
f	Barley, 7 bushels	—	24·5
g	Clover for mowing	10	—
h i k	Pasturage	30	—
		140 deg.	117 deg.

Gained 23 degrees in ten years.

No. 5.—Rotation of Twelve Years with Pasturage.

		Increase of Fertility.	Decrease of Fertility.
a	Fallow	10 degrees.	— degrees.
	3 1-7 loads of manure	31·25	—
b	Rye, 6½ bushels	—	32·5
c	Barley, 6½ bushels	—	22·75
d	Oats, 5 bushels	—	12·5
e	Fallow	10	—
	6 loads of manure	60	—
f	Rye, 7 bushels	—	35
g	Barley, 6 bushels	—	21
h	Oats, 5 bushels	—	12·5
i	Clover for mowing	10	—
k l m	Pasturage	30	—
		151¼ deg.	136¼ deg.

Increase of fertility in twelve years, 15 degrees.

No. 6.—The Rotation of Ten Years as practised in Holstein.

		Increase of Fertility.	Decrease of Fertility.
a	Oats sown on the broken-up pasturage, 11 bushels	— degrees.	37·5 deg.
b	Fallow	12	—
	8 loads of manure	80	—
c	Rye, 9 bushels	—	45
d	Barley, 9 bushels	—	31·5
e	Rye, 4 bushels	—	20

		Increase of Fertility.	Decrease of Fertility.
f	Clover for mowing	10	—
g h i k	Pasturage	40	—
		142 deg.	124 deg.

Gained in ten years, 18 degrees of fertility.

No. 7.—Rotation of Eight Years with alternate Cultivation and Pasturage.

		Increase of Fertility.	Decrease of Fertility.
a	9 loads of manure	90 degrees.	— degrees.
	Potatoes	10	30
b	9 bushels of Barley	—	31·5
c	Peas	—	10
	3¾ loads of manure	37·5	—
d	8 bushels of Rye	—	40
e	Clover for mowing	12	—
f g	Pasturage	20	—
h	Oats on the broken-up pasture ground	—	27·5
		165½ deg.	139 deg.

Increase of fertility in eight years, 30½ degrees.

No. 8.—Rotation of Eight Years, with alternate Cultivation and Stall-Feeding of Cattle.

		Increase of Fertility.	Decrease of Fertility.
a	9 loads of manure	90 degrees.	— degrees.
	Potatoes, 80 bushels	10	30
b	Barley, 11 bushels	—	38·5
c	Clover	15	—
d	Oats, 13 bushels	—	32·5
e	6⅔ loads of manure	66·66	—
	Peas	—	10
f	Rye, 9 bushels	—	45
g	Green vetches	10	—
h	Rye, 8 bushels	—	40
		191⅔ deg.	196 deg.

Loss of 4⅓ degrees of fertility in eight years.

No. 9.—Rotation of Ten Years, with alternate Cultivation, Stable-Feeding of Horses and Cattle, and Two Years of Pasturage for Sheep.

		Increase of Fertility.	Decrease of Fertility.
a	Oats on broken-up pasture, 13 bushels	— degrees.	32·5 deg.
b	Green vetches on a fallow	10	—
	Pasturage of 1,500 sheep—per acre	40	—
c	Rye, 9 bushels	—	45
d	Peas	—	10
	3 loads of manure	30	—
e	Rye, 8 bushels	—	40
f	Potatoes	10	30
	10 loads of manure	100	—
g	Barley, 11 bushels	—	38·5
h	Clover	15	—
i k	Pasturage	30	—
		235 deg.	196 deg.

Increase of fertility during ten years, 39 degrees.*

Those agricultural systems, therefore, which are based upon this rotation, are infinitely more ameliorating, and more likely to produce valuable crops of plants and vegetables, such as wheat, cabbages, and others intended for sale; they are also likely to increase the profits of sheep-husbandry very considerably, which would, doubtless, be much greater than they are at present, if the breeds were improved and properly attended to.

The cases or situations in which a farmer can procure manure from any extraneous sources, independent of that produced by his own cattle and establishment, are of such rare occurrence that it is scarcely worth while to notice them at all

* The result of the rotation No. 9 shows the benefits of alternate cropping, as has been long ago proved in this country. The knowledge and use of green crops, esculent and herbaceous, must soon banish fallows from the foregoing rotations, for the growth of rye and barley would suppose a capability in the soil of being beneficially used in producing these invaluable plants.

in this place. Nevertheless, as they are frequently spoken of, although they can only exist in the neighborhood of large towns; and as manure is often estimated at the price which it fetches under such circumstances, we will devote a few observations to the subject.

The only means of discovering the actual value of manure is to compare the produce of an acre of land which has been plentifully and repeatedly manured, with the amount which it yielded when only the necessary quantity of manure was bestowed on it, and that at distant intervals.

In the third volume of my English Agriculture, page 461, *et seq.*, I have given some account of this expense, derived from information which I obtained from country people, and the results of which were that the real value of a load of manure was 6 rix-dollars and 9 groschen. But, in order to be convinced that it is correct after having calculated the produce of the triennial rotation, as given at page 79, let us suppose, on the other hand, that we could procure sufficient manure to enable us to bestow an amelioration of six loads every three years; and to avoid, as much as possible, diverging from the triennial rotation, we will take the following succession as a basis:

1. Fallow manured.	4. Peas manured.	7. Potatoes manured.
2. Cabbage or turnips	5. Rye.	8. Barley.
3. Wheat.	6. Barley.	9. Rye.

We must now calculate the value of all these products, according to the proportion of nutritive matter which the soil contains; and then, by deducting the extra expenses which cultivation of them occasions, the value of the manure will immediately become evident.

But the real value of manure is increased by the fact, that it progressively augments itself; and that, besides the produce it yields, an extra quantity of manure will, if properly bestowed, never fail to produce the elements of a fresh supply, so that it will soon be possible to cultivate those plants successively, from which the largest sum of money may be realized. On the other hand, the manure diminishes in like proportion if once a scarcity is allowed to be felt, and an immediate and suitable remedy be not found and applied. One of the consequences of a scarcity or diminution of manure, is a scarcity of straw; and where there is little straw or fodder, little dung can be obtained, and thus the quantity of manure progressively dwindles away until the soil becomes totally exhausted. However expensive it may be to bestow this first extra quantity of manure on a soil which has been impoverished, there certainly is no capital better employed than that which is expended in this manner.*

In order to prevent misunderstanding with regard to the quantity and weight or measure of this manure, we shall here lay down some principles from which neither absolute uniformity nor mathematical precision must at all times be expected, but which may, however, be taken as general averages.

The usual load for a wagon drawn by four horses is thirty-six cubic feet of stable manure, half reduced, and in the state in which it is usually applied to the land. In this state—that is to say, when the straw has become soft and disorganized, without being wholly decomposed, and the dung is moist and yet not very watery—a cubic foot of it will weigh 56 lbs.; therefore a load of thirty-six feet contains 2,016 lbs., which, for the sake of obtaining round numbers, we will reduce to 2,000 lbs. Where the roads are good and the weather favorable, this load may, doubtless, be increased; but as a period of fine weather is seldom

* The author recommends the quantity of manure on any farm never to be suffered to grow less; and that some extraneous source be discovered, if possible, whence to support the quantity; and finally, to create a progressive augmentation. If the crops be allowed to diminish in bulk, the quantity of dung will decrease proportionably, and end in the complete exhaustion of the farm. He observes that no expense must be grudged to fill with manure all the lands that are cultivated, and more especially on those soils that have been exhausted by previous mismanagement; and in the whole course of his writings, most certainly he has not made a greater or more valuable display of practical skill. On such lands the utmost limit of skill in cultivation and in cropping may be exerted, and with very little effect; years will be passed in a very heartless occupation, and time and labor will be expended with no corresponding result. On the essential expense that is required to produce the first crops, in order to yield the elements and means of raising others, most cultivators in our country stumble and founder, from want of calculation of the probable repayment; for, as before observed by the author, they cannot view capital as existing in any form other than in money in a bank or in coffers; and these contracted views produce a universal stagnation. Notwithstanding the many splendid examples of capital that had been judiciously expended. now repaying an ample premium on the amount, money employed in this manner is expended, on the most solid security; panics and failures and bankruptcies do not affect it.

chosen for carrying manure, this quantity will in general be found to be tolerably correct.

If the straw is not decomposed or altered, a cubic foot, closely packed, will not weigh more than 48 lbs.; and in this case the volume or size of the load is increased, and contains from forty-five to forty-six cubic feet of manure.

When eight of these loads are distributed over an acre of land, it is considered that a good covering has been given; each square perch then receives 88·8 lbs. of manure, and each square foot nearly 0·6 lbs. If only five of these loads be allowed for each acre, as is generally the case, it is said then that the ground has been slightly manured, and each square perch receives about 55 lbs. And lastly, if twelve loads are spread over each acre, which must never occur where cereal crops are to be grown, unless the land has been completely exhausted, then the ground is said to have received an abundant manuring.

It is customary to allow only one-half the weight and quantity above mentioned when the manure is derived entirely from sheep, because the effects which it produces are at once greater, more prompt, but less efficacious in point of durability.

The periods of these ameliorations occur every three, four, six, or nine years; the more frequently they are applied, the slighter they are; and the longer the intervals the more abundant must the manuring be, unless, indeed, scarcity compels the farmer to manure very moderately. Thus, in forming a calculation relative to the distribution of manure, it is necessary to take into account not only the quantity which is to be laid on at each separate application, but likewise the number of times that this amendment must be repeated, and the quantity which will be requisite for a certain number of years.

As it seldom happens that a farmer can procure manure in any manner which will prove cheaper or more advantageous than by deriving it from his own cattle and establishment, many persons have endeavored for some time past to determine the relative proportions that ought to exist between the number of cattle kept and the extent of the cultivation of corn, in order that both may tend to produce the highest amount of profit which can be attained. The multiplication of the number of cattle raises the produce of the cultivation by increasing the quantity of manure which is made; and the ameliorations thus bestowed on the soil in their turn increase the profit of the cattle by augmenting the crops destined for their food. This reciprocal influence is the great balance-wheel of every well-regulated agricultural undertaking; and the least acceleration of its motion at any period, or the slightest inclination to one side or to the other, communicates itself to the whole machinery, and multiplies or diminishes the powers of action and their results.

In order to discover the just proportion of each of these objects in every locality, the persons before alluded to have commenced with the cattle, and have sought to determine how many of such a breed or species ought to be kept upon a given surface. One ox or cow has generally been considered as equivalent to one horse, ten sheep, or six pigs. But it was soon observed that there great differences even between individuals of the same breed and kind, both as regarded the size of the animals and the quantity of food which they consumed; and that it was also necessary to take these circumstances into consideration. One of the most perfect calculations on this subject, founded on an average taken from several different data, will be found in Borgstede's work.* The author, in the first place, notices the straw and other component parts of the litter; he classes them thus:—

(1.) Countries in which straw is very plentiful, so much so, indeed, that, in general, from 1,500 to 1,800 sheaves of straw, and even more, may be reckoned for every winspel of seeds; a winspel of seed is generally equal to about twenty acres, which allows from 75 to to 90 sheaves per acre, and the weight of a sheaf of straw of spring or autumnal corn is usually about 10⅔ lbs.; the whole will, therefore, amount to from 800 to 960 lbs.

(2.) Countries in which from 1,350 to 1,500 sheaves of straw are obtained for every winspel of seeds, from 67½ to 75 sheaves per acre, and about 720 to 800 pounds.

* Grundsatzen uber die "General verpachtungen der domainen in den preussischen Staaten." Berlin, 1785.

(3.) Countries which produce only a smaller quantity of sheaves, never amounting to 1,350, and in which there is consequently a scarcity of straw for litter.

(4.) Countries in which they are compelled to make use of other substances and extraneous matters, to supply the place of the straw as litter.

(5.) Countries in which they are able to supply this deficiency by straw purchased at a reasonable price.

In No. 1, the cattle are supposed to be turned into the pasture lands about the middle of May, and not taken back into the stalls until the middle of November.

In No. 2, the cattle are supposed to be turned out towards the end of March, and not brought up again until the middle of December.

In No. 3, the cattle are supposed to be fed entirely in the stalls.

No. 4, indicates the dung resulting from 100 sheep, which were not pastured.

In No. 5, the animals are supposed to have been depastured during five months of the year, and confined in the sheep-fold all night during the other seven months.

Nicolai, in his work entitled, "Principles for the Regulation of Estates," says:

One ox or cow yields 10 loads of dung, for a two-horse wagon.

One young ox or cow yields 5 loads of dung, for a two-horse wagon.

One horse fed in the stable yields 15 loads of dung for a two-horse wagon.

One horse turned out to grass yields $7\frac{1}{2}$ loads of dung, for a two horse wagon.

One hundred sheep yield 100 loads of dung for a two-horse wagon.

He likewise states, that half as much dung as is obtained from the horned cattle, may be derived from the pigs, the poultry, and the farm-yard, provided that care is taken to keep the latter place well provided with straw.

He allows twenty of these loads of the dung of cattle per acre, eighteen of horse dung, twenty-five loads of the mixed manure derived from the farm yard, &c., and fifteen loads of the dung of sheep.

Consequently, an ox manures $\frac{1}{2}$ an acre; a young ox or cow, $\frac{1}{4}$ of an acre; a horse fed in the stable, 5-6th of an acre; and a hundred sheep, $6\frac{2}{3}$ acres.

These loads for two horses cannot contain 1,000 lbs. because an amelioration of 20,000 lbs. per acre would be something extraordinary. The system here mentioned of obtaining manure by strewing great quantities of straw about the farm-yard, is, in my opinion, very far from beneficial; as the fields which were manured with dung thus composed, would derive little improvement from it.

Frédersdorf, in his "Valuations of Estates," reckons, that each cow that has been well kept, and has been allowed about 150 sheaves for litter, will produce six four-horse loads of dung; and if stall-fed during the whole year, that she will produce ten four-horse loads of dung. That each horse which receives a truss and a half of straw per day, will produce seven loads and a half of manure. He considers the dung of fifteen sheep, or of four or five full grown pigs, to be equal to that of one cow.

According to Karbe, sixty-five cows will manure a hundred acres, when they are turned out to pasture all day during the summer, and brought up to the cow-house at night; he states the proportion between horses or mares, and cows, to be as 2 to 3; and the proportion between stall-fed oxen as 3 to 2. A hundred sheep will manure ten acres.

Pfeiffer states, that a cow fed in the stall will yield 200 quintals of manure; and an ox put up to fatten, 80 quintals.

According to Leopold, four cows fed in the stalls yielded fifty loads of manure, six of which were sufficient for an acre of land.

In a paper by a very talented agriculturist, and a man of some experience in the "Annales de l'Agriculture de Basse Saxe," année 5, section 1, page 129, the following statement of the proportion of the quantity of manure furnished by different animals will be found:—

If the dung of an ox or cow amounts to....	180	That of a sheep, to........................	10
That of a horse amounts to..............	170	And that of a pig, to......................	18

The manure produced in his undertaking during the space of three years, was distributed according to this proportion, and he found that

Each ox or cow	had produced	7·789	loads for a wagon drawn by four horses.
" Horse	"	7·357	"
" Sheep	"	0·432	"
" Pig	"	0·778	"

These wagons from the manner in which they were loaded, probably contained from 22 to 24 quintals each.

These data are strikingly vague, contradictory, and indefinite, leaving the many variations which occur with regard to the weight and bulk of a load of manure, totally out of the question; it is impossible to form a correct estimate of the quantity of manure which will be made by a certain number of animals, unless the quantity of fodder and litter consumed, and the manner in which the cattle are kept, be previously determined.

No average proportion can be given of the quantity of manure which cattle will produce, because when they receive an abundance of food containing a great proportion of succulent matters, the manure they will yield, both in straw and litter, and in excrement, will be seven or eight times as much as would be furnished if they were fed on dry food. In the former case, it is scarcely possible to give the cattle a sufficiency of litter; the dung ought to be carried out every day, or at least to be thrown back, otherwise the animals would stand in dirt and filth; in the latter case, on the contrary, straw which has formed the litter for a month or more, will be found to be scarcely soiled or wetted. The size of the cattle has some influence on the quantity of manure derived from them.

Cattle can only be considered as machines that appropriate a very small portion of the fodder which they consume to their own subsistence, while they reduce the greatest portion of it to dung. By dung, we understand not only the larger excrements properly so called, but also the urine, and some portion of the perspiration which is absorbed by the straw; this dung is not entirely composed of the residue of the fodder, but also contains some portions of the animal organization, which, in the course of nature, are detached, evacuated, and replaced by new formations. Thus the dung loses a great part of its vegetable nature, and acquires animal properties instead.

The experiments hitherto made have been insufficient to determine whether the mass of consumed and digested fodder is found to be augmented or diminished, when, by extracting the aqueous principle, it is reduced to a state of dryness. It is most probably diminished, since the augmentation of the animal frame, the growth of hair or wool, and the secretion of milk, must absorb some portion of the aliments. It is, however, only a very trifling portion that is thus absorbed, and it is not yet decided whether the water which the animal drinks, and the gaseous substances which are otherwise imbibed, are not decomposed in the body until they form a solid matter. At any rate, it is certain, that by means of the additional humidity, the excrements weigh above half as much more than the dry food, if we weigh them in the moist state in which we use manure.

The superabundant moisture, particularly the urine, which we must not consider simply as water, but rather as a fluid containing a great number of very active solid animal particles; this moisture I say is absorbed by the litter, and thus augments the mass.

There is very great difficulty in determining the relative proportions which exist between the dung on the one side, and the fodder and litter consumed on the other. This accounts for the constant variations, trifling though they be, which are observable in the results of all the experiments made with a view of determining this point. There is still more difficulty and uncertainty in determining the bulk of the dung from that of the fodder, because the former depends on the greater or less degree of moisture and compression, as well as on the state of decomposition in which the straw, and other filaceous substances, happen to exist; all which circumstances have more effect on the bulk than they have on the weight. Nevertheless, the experiments hitherto made, whether on a small scale, by weighing the larger excrements by themselves, or in conjunction with the urine absorbed by the straw, or in all their various degrees of decomposition, or in that state when the manure does not give out any water, even from compression; or on a large scale, by determining as nearly as possible, by weight, the quantity of dung which is carried, and comparing it with the weight of fodder and litter consumed; these experiments, I say, are sufficiently in accordance with each other to prove that the mass of dry food and litter is rendered twice as heavy by the transformation into dung.

But, in order to produce this effect, the dung must be properly attended to, and as much straw used for litter as will be sufficient to absorb the fluids; for, should

there be too much, it will not be properly impregnated with moisture, and, consequently, will not attain that increase of weight which was just mentioned; and should the litter be too thin and scanty, it will not retain the urine at all. The necessary quantity of litter cannot be determined by the number of cattle; it ought rather to be regulated by the quantity and quality of the fodder consumed, and the excrements produced from it.

Both the dry aliments destined for cattle, and those which have preserved their succulent properties, vary in nutritive powers, although they be of equal weight. Thus, a greater number of cattle can be profitably fed on a certain weight of succulent food, than could be kept in condition by an equal quantity of dry fodder. Amongst cattle equally well fed, the larger excrements of those kept on substantial food frequently appear less bulky than of others fed on a greater proportion of less succulent aliments; but the quantity of larger excrements and urine voided by animals is not always in direct proportion with the amount of fodder which they consume.

A horse fed for the most part on corn will yield almost, if not quite, as much dung as one that consumes twice that weight of hay only. This is one reason that the nutritious properties and powers, as well as the weight of dry fodder, should be regarded; because what is wanting in quantity when the animals are fed on substantial fodder, is doubtless, made up by the quality of the dung, and by the greater number of animal particles which it contains.

The worthy and talented commissioner, General Meyer, is the first writer who has given us an exact account, founded on well-attested experiments, of the quantity of dung which will be produced by a certain weight of fodder and litter. He gives to the straw the moisture which it derives from the urine, and, guided by these experiments, he supposes this increase to be as 2·7, when only the necessary and proper quantity of litter is laid down; and under the title of "litter," he also comprises the straw given as food, because it contributes little or nothing towards the nourishment of the animal. He allows only 1·8 for the augmentation occasioned by the moisture added to the hay which is consumed, on account of the nutrition derived from this kind of fodder by the animal frame. Those vegetables which retain their succulent properties are classed by him with the hay, but only according to their weight when reduced to a state of dryness. Lastly, he attributes a much greater augmentation to grain when transformed into dung, than they would derive according to the previous proportion; insisting that their weight is increased from 3 to 3·7.

According to the results of numerous experiments, and particularly of several trials which were made, with great care and precision, during the winter of 1808–9, on some oxen put up to fatten, it appears that we shall be very near the truth when we admit that the weight of hay and straw consumed, as well as that of litter just sufficient to absorb all the urine, will be doubled by its transformation into dung. The quantity of dung likely to be produced might be calculated with much more accuracy in this manner than it could be ascertained by any reference to the number of cattle.

We are left in still greater uncertainty with regard to the quantity of manure which may be obtained by feeding the cattle with a given quantity of succulent vegetables, because no satisfactory experiments on a sufficient number of animals, or continued for a sufficient period, have as yet been made on this point. Nevertheless, from several observations which I have had the opportunity of making respecting the use of potatoes, on extensive farms, where great quantities of this vegetable are grown and given to the cattle as their chief food, I find that, when transformed into dung, they lose at least two-fifths of their original weight, especially if the increase of weight above-mentioned be attributed to the straw consumed with them.

But this mode of proceeding does not do justice to the potatoes, for the chief part of the augmentation of weight in the straw proceeds from them; and without the aid of a good stock of these roots, fewer cattle could be kept, and there would, consequently, be a diminution in the supply of the urine, by which the litter is changed into dung and its weight increased.

With regard to the potato haulm or straw, according to an experiment made in 1809, an acre of that substance, which appeared to be thin or fine haulm, when cut and perfectly dry,

Weighed	907 lbs.
A similar extent of large potato haulm weighed	605 "
	1,512 lbs.

The average weight would be 756 lbs.

The quantity of albumen which this haulm contains, renders it in general much preferable to straw.

There is no doubt that an accurate knowledge of the nutritive powers of different vegetables would enable us to form some tolerably close calculations respecting the quantity of manure which they would produce. Experiments have been made with regard to these nutritive powers, both in fattening cattle and by chemical analysis, and the results of both methods have been in accordance with one another. I therefore propose, at once, to begin and point out all the most essential facts with regard to the nutritive properties of the vegetables in common use, for this will be a necessary preliminary in order to render perfect those details of rural economy into which we shall have occasion to enter.

As hay is more known and more used than any of the other kinds of fodder, I shall make that article the standard by which all the others may be compared.

According to the researches of Einhoff, which he did not, however, regard as sufficiently accurate and complete to be submitted to the public, one hundred parts of good hay contain only about fifty parts of what may be regarded as nutritive matter.

If 100 parts of good potatoes, which are neither aqueous nor spongy, are dried to about the same degree as hay, after this process there will remain only 30 parts, and 25 of which may really be regarded as nutritive matter. Thus, in the feeding of cattle, 100 lbs., or one bushel of potatoes, may be regarded as equal to 50 lbs. of hay; and this proportion will be found to be borne out by almost all general observations made on the fattening of cattle; for when an ox put up to fatten receives 60 lbs. of potatoes per day, he thrives equally as well as on 30 lbs. of hay.

Beet-root contains only eight parts in 100 of actual nutritive matter; but it likewise contains four parts of filaceous substances, which is very difficult to decompose; and as it is yet uncertain how far these latter substances may contribute towards nutrition, we will suppose this vegetable to contain ten nutritive parts in every 100.*

The Ruta-bagas contain twelve parts in every 100 of matter decidedly nutritive, and rather more than three parts of filaceous substances, which are with difficulty decomposed. The turnip cabbage contains about the same proportions.†

Thus 100 lbs. of hay, 200 lbs. of Potatoes, 500 lbs. of beet-root, and 370 lbs. of ruta-baga, probably each contain an equal portion of nutritious matters.

These two last-mentioned vegetables likewise produce a great many leaves; the leaves of the beet-root are most numerous, and contain the greater proportion of succulent matter, and are the most aqueous. Those of the ruta-baga, on the contrary, are fewer, but they contain more albumen,‡ and, consequently, are more nourishing.

If, in our valuation of these roots, we leave the haulm quite out of the question, and attribute no portion of weight to it, we may, without hesitation, admit that 460 lbs. of beet-root and 350 lbs. of ruta-bagas are equal to 200 lbs. of potatoes and 100 lbs. of good hay.

Einhoff has not completed his analysis of these vegetables. Nevertheless, after

* I cannot comprehend how Einhoff could possibly distinguish which parts really were the nutritive portions of any vegetable, or how he could discover the actual degree of nutrition which these portions contained, unless it was by means of direct experiments on the feeding of animals; but I have strong reasons for believing that beet root is much more nutritious than the author has here stated. Leaving the assertions of the Abbé Rosier, which certainly are exaggerated, totally out of the question, I am led to believe from an account which there is in "La Bibliot Brit." No. 338, p. 42, of an experiment made in the winter of 1809–10, on twenty-four sheep, that 252 lbs. of beet root, if used two months after the gathering of the crop, will be found equal to 100 lbs. of hay. Subsequent experience has convinced me of the truth of this proportion. [*French Trans.*

† I was also induced, by the above-mentioned experiment, to believe that 234 lbs. of Ruta-baga grown on argillaceous land, are equal in nutritive powers to 100 lbs. of good hay; 239 lbs. of raw potatoes, and 222 lbs. of these roots, when cooked, have also appeared to me to be equal to a quintal of hay; but as all the crops of this vegetable grown in 1809, were, evidently, very aqueous, I can agree with the opinion of Einhoff on this point. I also perfectly coincide in his opinions with regard to carrots, lucerne, and clover. [*French Trans.*

‡ A substance of the same nature as the yolk of an egg.

a very superficial examination, and comparing them with the ruta-bagas, he came to the conclusion that, with regard to nutritive properties, their reciprocal relation was as 2 to 3. Thus, 525 lbs. of roots would be equal to 100 lbs. of hay.

The same may be said with regard to carrots, which really contain a great number of aqueous parts, and also a great deal of albumen and sugar. We are enabled from the experiments of Einhoff, as well as from the observations of different persons while employed in fattening cattle, to ascertain that their relation to potatoes is as 3 to 4; thus 266⅔ lbs. of carrots are equal to 100 lbs. of hay.

White cabbages have not, as yet, been analyzed; but, from the experiments which have been made with regard to fattening cattle, their proportion, when compared with potatoes, is as 1 to 3: thus 600 lbs. of white cabbage are equivalent to 100 lbs. of hay. Clover, if cut at the period when its flower is just opening, loses 80 parts of 100 in drying; but both experience and chemical analysis tend to prove that this plant contains a far greater portion of nutritive juices than hay grown in natural meadows, and that the stalk in particular, like that of all plants belonging to the diadelphous class, contains a great deal of albumen and sugar. 90 lbs. of young, dry clover may, consequently, be regarded as equal to 100 lbs. of common meadow hay.

Vetches, if cut when young, bear about the same proportion; if they are suffered to grow older, the increase of size on the one hand, and the formation of the husk and seed on the other, compensate for the diminution of succulency in the stalk and leaves. Neither can we give any reason that the same value may not be assigned to lucerne and saintfoin. It does not, however, appear to me that we have any proof that these plants lose nothing by being dried, or that they contain the same quantity of nutritive matter when reduced to dry fodder, as they did while green; in fact, it is exceedingly improbable that no portion whatever, excepting the water, is evaporated during the process of drying; but it possibly might happen that the fibrous parts, which could before be easily decomposed, have become more difficult of dissolution.

We may then consider that, for feeding cattle, the following proportions will be found to be equally nutritious and beneficial:

Hay.	Potatoes.	Beet-root.	Ruta-baga.	Radishes.	Carrots.	White Cabbage.
100 lbs.	200 lbs.	460 lbs.	350 lbs.	525 lbs.	266 lbs.	600 lbs.

Young Clover.	Vetches dry.	Lucerne dry.	Saintfoin dry.
90 lbs.	90 lbs.	90 lbs.	90 lbs.

In order the better to attain our object, and to ascertain the proportion between the quantity of nutriment which may be obtained and that of the dung which it will produce, it is necessary that we should previously determine the average amount of plants and vegetables which may be raised on an acre of land, always supposing that a proper kind of soil and a suitable degree of cultivation are employed. We shall enter more fully into this subject when we come to the part of the work that is more especially devoted to what relates to these vegetables; and there we shall describe the basis on which the valuation given in the preceding section is founded.

At p. 23, we divided meadow land into five classes, by taking the greater or less amount of produce which it yielded, as the basis of the classification; these divisions will be more accurately and precisely defined in the sequel. Meadow land of the first class is seldom met with; and, as a meadow must be in very tolerable condition to enable it to yield 1600 lbs. in two crops or mowings, we will take this quantity as the average produce.

It is frequently reckoned that the clover crops will produce from thirty to forty cwts. of hay per acre; but the soil must be particularly rich, fertile, and calcareous, to yield this quantity, although it is argillaceous in constitution.

On a common argilo-sandy soil which has been deeply and carefully plowed, which is submitted to a judicious rotation, and on which the clover is properly sown, an average crop of 2,400 lbs. at two mowings, or 1,600 lbs. at one cutting, may in geneal be confidently reckoned upon, and five times that weight in green fodder. In moist and fertile years, when both crops are equally good, the produce of the clover will far exceed this average; but in dry years, when one crop is scanty, it will frequently be far below it.

Rich and thickly-planted lucerne ought to yield 4,000 lbs. of dry fodder, if the

soil and climate be suitable for it. Saintfoin, if sown on a soil appropriate to its nature, will yield 2,000 lbs. of dry fodder per acre. Vetches, or the mixed crop of which they form a portion, will yield at least 2,000 lbs. of dry fodder when they have been manured. When they have not been manured, and the soil is, nevertheless, in good condition, this produce is reduced to 1,200 lbs.

A crop of potatoes, sown on a warm soil, which has been deeply plowed, well manured, and has received a very careful culture, will yield 80 bushels per acre, or 8,000 lbs. over and above the seed. The amount here mentioned is rather below than above the average produce of a good and carefully-cultivated soil; I have, myself, repeatedly raised a crop of 12,000 lbs. per acre in ordinary years. But I would rather that my valuation of this, and of all other crops of roots, should be below their average produce than above it,* in order to do away with the suspicion, which many seem to entertain, that I speak more favorably of them than they deserve, from having a predilection for that root.†

Beet-root yielded	20,000 lbs.	of roots per acre.
Ruta-baga and turnip cabbage	20,000 lbs.	" "
Carrots	18,000 lbs.	" "
Cabbages, if sown on a soil suited to them	36,000 lbs.	" "

Thus, then, the produce of an acre of potatoes may be regarded as equal in nutritive power to .... 4,000 lbs. of hay.

That of an acre of Beet-root as equal to	4,347, or 4,300	"
" " Ruta-bagas	5,700	"
" " Radishes	3,800	"
" " Carrots	6,700	"
" " Cabbages	6,000	"
" " Clover, at two mowings	2,600	"
" " Lucerne	4,400	"
" " Saintfoin	2,200	"
" " Vetches, when manured	2,200	"
" " " not manured	1,300	"

In every case I have supposed these vegetables to be grown on a soil which is suitable to them, and which has been for some considerable period ameliorated by careful culture, and has been properly manured. It must also be understood that these products are calculated from an average taken from several successive years, since there always will be seasons in which some of the crops turn out badly, and others, on the contrary, in which they yield far more than the usual amount of produce; this consideration ought also to induce us to cultivate several different kinds of crops, in order that the gain on some of them may compensate for the loss in others.

If we collect the excrements and urine of those animals which have been fed on plants or vegetables containing a great proportion of succulent matter, and keep them separate from any other substances, we shall, doubtless, find that this dung will bear more relation to the nutritive powers than to the weight of the food. The lesser weight of the more solid aliments will be compensated by the greater quantity of water which the animals will drink while consuming them. Thus, 200 lbs of potatoes, 350 lbs. ruta-bagas, 600 lbs. of cabbages, or 50 lbs. of oats, will singly produce as much dung as 100 lbs. of hay; for each of these quantities will afford an equal degree of nourishment to cattle. But if we allow the excrements to be collected with the straw, and attribute to it, and not to the excrement, the increase of weight which the latter derives from the liquid portions, the proportion of these will be modified. Those aliments which contain the smallest portion of indissoluble fibres, will yield the least quantity of large excrements. This accounts for the fact that exceedingly succulent vegetables do not stand in that proportion to hay, with regard to the dung which they produce, as they do with regard to nutritive properties.

We have not, as yet, had any sufficient or definite proofs of the quantity of dung produced by most of the vegetables given as food; the only experiments from which clear and certain results were deduced, are those which have been made on potatoes. It would appear, from the average of those results which I have

* The crop of potatoes at 80 bushels beyond the seed, or 100 bushels, seems very low; and, allowing the German to be two-thirds of our acre, the crop will only amount to 150 bushels; and the scheffel being about one and a-half bushels, the whole amount little exceeds 200 bushels.

† These weights are much below the usual produce in England.

stated at p. 91, that 100 lbs. of potatoes will produce 60 lbs. of dung; and that thus, an acre of potatoes which yields 80 bushels, or 8,000 lbs. above the seed, and is equal to 4,000 lbs. of hay, will produce 4,800 lbs. of dung, without reckoning that produced by the haulm, which amounts to 1,512 lbs. on account of the weight being doubled of that portion, when reduced to a state of dryness. It will weigh this amount whether it be given to the cattle as food while green, or dried and used as litter instead of straw. Therefore, by uniting these two sums, we shall find the average amount of dung produced by an acre of potatoes, to be 6,312 lbs.

As experience has not, hitherto, furnished us with any data from which we can derive any positive information with regard to the other plants used for fodder, we will suppose their produce in dung to be equal to that of potatoes, calculated not according to weight, but according to the number of acres, without allowing anything for the additional quantity of nutritive matter their extra amount of produce may contain.

We shall, likewise, suppose clover and lucerne to be the same in this respect as natural hay, notwithstanding the superiority which they possess over the latter in point of actual nutriment.

We shall, therefore, reckon that—

One acre of	Potatoes, or any other vegetable or root, will yield	6,312 lbs.	of dung.
"	Clover, in two mowings	5,200	"
"	Clover, in one mowing	3,200	"
"	Lucerne	8,800	"
"	Saintfoin	4,400	"
"	Vetches, manured	4,400	"
"	Ditto, not manured	2,600	"

Independent of the additional weight which the straw will produce.

In 1805 I obtained sufficient dung from the consumption of 25 acres of green peas, with about 1,500 sheaves of straw as litter, and a small quantity of pine leaves, to manure 30 acres of autumnal corn that year.

With regard to the other part of the dung, namely, that which is produced by the straw, we have lately obtained some information which may be depended on. It is true that we have not hitherto wanted for data with regard to the quantity of sheaves which a certain extent of each kind of land will produce, or of the number of trusses of straw which ought to be derived from each species of grain; but yet we lacked any certain and invariable data with regard to the average weight of these sheaves or trusses. Every agriculturist and farmer who has gone beyond the confines of his own property, well knows that there are vast and almost incredible differences with regard to this matter; that, in some places, the sheaves only weigh 8 lbs. while in others they weigh from 40 lbs. to 50 lbs. And the difference in the weight of the trusses is equally great, varying from 10 lbs. to 40 lbs. Hitherto, however, most persons have thought that they explained themselves sufficiently clear, when they stated the average amount of their crops according to their own system of proceeding.

It is generally considered that we may derive a tolerably exact notion from experience what amount of produce in corn may be expected from certain kinds of soil or systems of cultivation; and it is very true that where sufficient attention is paid to the subject, we may learn much in that manner.

But Commissioner General Meyer is the first person I ever knew who has systematically endeavored to deduce the produce in straw from that of grain. No one, however, can be ignorant that there is an existing proportion between these two articles of produce. Every experienced farmer can calculate the amount of grain which one of his sheaves will yield; and after the first threshing he is able to say whether these sheaves yield well or only middling, or very badly in that year. The variations which frequently occur on the same soil, and under the same kind of cultivation, are therefore exceptions to the general rule. If a favorable state of weather has caused the corn to shoot up quickly at first, to put forth a number of blades, and at the time of flowering the exceeding richness of the soil causes it to fall to the ground; or if bad weather, or the various diseases to which corn is subject, impede development of the grain: or lastly, if at harvest time the corn should be laid, then will the proportion of grain to straw be much less than usual. But if, on the other hand, a continuation of bad weather should stint the growth of the corn, or destroy a great number of the plants; or if mice or insects should thin the crop, and after-

wards an interval of fine weather should intervene—which promotes the development of the ears, the fecundity of the flowers, and tends to mature and ripen the grain—then will the proportion of straw to that of the corn be much less than usual. But it is impossible to take all these exceptions into account while forming a general estimate of the results of rural economy.

According to most of the observations and experiments which I have heard of, or which have been communicated to me, the proportion of grain to straw varies,

In Rye, from 38 to 42 in 100; Wheat, from 48 to 52 in 100; Barley, from 62 to 64 in 100; Oats, from 60 to 62 in 100.

It is still more uncertain with regard to peas, for it is well-known that there is no average with regard to the number of legumes that one plant will bear. The loss or diminution which this plant may sustain during the harvest or gathering, must likewise be taken into consideration. The Count Von Podewils has stated the proportion of grain to straw in this case to be as 5 to 21; but, if my opinion were asked, I should say we were much nearer the mark if we stated it to be as 35 to 100. The best mode of proceeding is to allow 2,000 lbs. of straw for each manured acre of peas, because in this crop the product in straw is much less casual than in grain. The same may be said with regard to vetches.

If, then, a bushel of rye, of full measure, weighs 86 lbs. and the average proportion of straw to grain be as 40 : 100, an acre of rye will yield a produce of—

3	bushels*	645	lbs. of straw, which,	in its turn,	yields	1,290	lbs. of dung.
4	"	186	"	"	"	1,720	"
5	"	1,075	"	"	"	2,150	"
6	"	1,290	"	"	"	2,580	"
7	"	1,505	"	"	"	3,010	"
8	"	1,720	"	"	"	3,440	"
9	"	1,935	"	"	"	3,870	"
10	"	2,150	"	"	"	4,300	"
11	"	2,365	"	"	"	4,730	"
12	"	2,580	"	"	"	5,160	"

If a bushel of wheat weighs 92 lbs. and the proportion of the grain to the straw be as 50 : 100, an acre will yield a produce of—

3	bushels	552	lbs. of straw, which,	in its turn,	yields	1,104	lbs. of dung.
4	"	736	"	"	"	1,472	"
5	"	920	"	"	"	1,840	"
6	"	1,104	"	"	"	2,208	"
7	"	1,288	"	"	"	2,576	"
8	"	1,472	"	"	"	2,944	"
9	"	1,656	"	"	"	3,312	"
10	"	1,840	"	"	"	3,680	"
11	"	2,024	"	"	"	4,048	"
12	"	2,208	"	"	"	4,416	"

If a bushel of barley weighs 68 lbs., and the proportion of the grain to the straw is as 63 : 100, an acre of land will yield in one crop—

3	bushels	324	lbs. of straw, which,	in its turn,	yields	698	lbs. of dung.
4	"	432	"	"	"	864	"
5	"	540	"	"	"	1,080	"
6	"	648	"	"	"	1,296	"
7	"	756	"	"	"	1,512	"
8	"	864	"	"	"	1,728	"
9	"	972	"	"	"	1,944	"
10	"	1,080	"	"	"	2,160	"
11	"	1,188	"	"	"	2,376	"
12	"	1,296	"	"	"	2,592	"

If a bushel of oats weighs 52 lbs., and the proportion of grain to straw is as 61 : 100, an acre of land will yield in one crop—

3	bushels	256	lbs. of straw,	which will	produce	512	lbs. of dung.
4	"	341	"	"	"	682	"
5	"	426	"	"	"	852	"
6	"	512	"	"	"	1,024	"
7	"	597	"	"	"	1,194	"
8	"	688	"	"	"	1,366	"
9	"	768	"	"	"	1,536	"
10	"	853	"	"	"	1,706	"
11	"	938	"	"	"	1,876	"
12	"	1,024	"	"	"	2,048	"

* The measure here translated "bushels," is about 1½ of our measure of that name.

In this estimate of the proportions in which dung may be obtained, it is always understood that the straw is employed for litter; or, should straw be scarce, those substances which are used instead shall be sufficiently plentiful, not only to receive and absorb all the different excrements, but likewise to enter into fermentation and become sufficiently decomposed without requiring any additional moisture; and, farther, that everything shall be so arranged that no portion of the urine shall be wasted or suffered to run off, and that the dung-steads shall be protected from the washing of heavy rains, which might carry away some portions of component parts. This dung, composed of animal and vegetable substances, is supposed to be lifted at the period when the incipient fermentation has commenced, and when the straw has become softened without being decomposed; in a word, in that state in which experience teaches all practical agriculturists when it can be used with the greatest advantage. There is a great deal of difference between the weight of fresh dung and of that which has become completely decomposed, and in which the straw is quite dissolved. The amount of the humidity has already been indicated in a previous page.

In order to discover the quantity of dung produced by pasturing animals, that evacuated by a cow fed on excellent pasture-land has been weighed, and it was found that, on an average, she produced 37 lbs. in a day and night; that is, 5,661 lbs. in five months, or one hundred and fifty-three days; the dung evacuated during the day was also weighed separately from that which was produced during the night, and it was found that the former amounted to from 21 lbs. to 23 lbs. and the latter to from 15 lbs. to 15¼ lbs. That dung which is evacuated by cattle on permanent pasture-land is lost for all agricultural purposes; but those farmers who use their fields alternately as pasture and arable land, derive some portion of benefit from it. Even then, however, it is not nearly so profitable as when mixed with the straw or litter in the stable or farm-yard, and properly collected. A great part of that evacuated in the fields is evaporated by the action of the sun and wind, or falls in the dust and is destroyed by insects; but the luxuriant tufts of grass which spring up wherever it falls, and the increased fertility of those parts of enclosed pastures on which the cattle lie down, or where they are milked, tends very satisfactorily to prove that it is not so completely wasted as some persons would have us to believe. In the rotations of crops with pasturage, in which it is usually the custom to leave the cattle in the field day and night, the dung thus made is already comprised in the ameliorating quality which we attributed to the repose or rest of the land.

But if the cattle which are depastured during the day are brought into the stable or farm-yard at night, the dung-heap ought necessarily to be augmented by the addition of their excrements. We reckon this part of the dung which will be produced by a cow, plentifully fed, at 2,500 lbs.; if she is not so well fed, as is usually the case with those that are pastured, it will amount to about 1,500 lbs.; and the straw of which the litter is composed must here be reckoned separately.*

With respect to the dung proceeding from the fodder consumed by cattle, and the straw or other substances composing the litter, no difference is made, in general estimates, between the various kinds or breeds of cattle by which it has been produced. We shall, however, offer a few observations on this subject.

The amount of dung which will be produced from the same quantity of food by lean, ill-conditioned, weakly cattle, will neither be so great, so rich, or so fertilizing; nor does it contain so much animal matter as that which is produced by strong, healthy and well-fed animals.

Sheep, if fed on the same quantity of provender, will produce dung which goes further, but the action of which is not so durable. These animals, however, appear to be decidedly the most advantageous for the manuring of pasture-land; the dung which they evacuate over the meadows is not only more equally diffused, but also amalgamates more freely with the soil, and acts more promptly on the vegetation. If the sheep are brought up from the pastures at night, and confined in a paddock or sheep-fold, they will produce a proportionally larger quantity of manure than cattle, supposing that each species has been allowed the same extent of pasturage. This reason causes the meadow and pasture-lands

* At the rate of 2 lbs. of dung to 1 lb. of straw.

in England, where it is customary to leave the sheep out night and day, gradually to become ameliorated and improved, and to be capable of feeding an increased number of these animals every year; when these lands are broken or plowed up, they are found to have acquired a much greater proportion of nutritive matter than those on which cows have been fed; indeed, these latter usually decrease in fertility about the third or fourth year, particularly where the soil is of a dry, hot nature.

When sheep are depastured, it is usually reckoned that 1,200 will yield about the same degree of amelioration to an acre of land, as would be produced by one-half of the quantity of stable manure generally allowed; 1,800 sheep are supposed to manure an acre and a half tolerably well, and 2,400 to manure it abundantly; so much so, indeed, as to render it too rich for most kinds of grain. If ten sheep, when pastured, are regarded as equivalent to one cow, and if one cow produces 15 lbs. of dung during the night, 180 cows will only produce 2,700 lbs. and 240 cows 3,600 lbs. which is not enough to manure one acre of land; but the effects and the nutritive properties of manure thus derived are much more permanent, and are retained much longer in the soil, than the dung of sheep.

In order to discover how far this estimate of the quantity of manure to be obtained, when founded on the consumption of fodder and straw, will agree with those which take for their basis the number of cattle, we will examine some of these latter which have been derived from experience, and drawn up from general averages, which may not, however, have been perfectly correct.

The table of the quantity of manure which may be derived from cattle (see *ante* p. 95) has peculiar relation to the mode of feeding adopted for the estimates in the electoral market and in the new market. According to this method, the following proportions are given to the different kinds of cattle:

	Straw from Winter Cereals.	Straw of Spring Cereals.	Hay.
For a large ox	3,600 lbs.	1,680 lbs.	1,650 lbs.
" Middle-sized ox	3,000	1,400	1,375
" Small ox	2,400	1,120	1,100
" Large cow	1,800	1,260	1,320
" Middle-sized cow	1,500	1,050	1,100
" Horse which is always fed in the stable	4,800	...	2,640

According to our system, the quantity of manure which would be derived from the above table would be as follows:

	Quantity of Fodder and Straw.	Dung.	Extent of Land which could be manured at the rate of 10,000 lbs. per acre.
For a large ox	6,930 lbs.	13,860 lbs.	1·38 lbs.
" Middle-sized ox	5,775	11,550	1·15
" Small ox	4,620	9,240	0·92
" Large cow	4,380	8,760	1
" Middle-sized cow	3,650	7,300	0·73
" Small cow	2,865	5,730	0·57
" Horse fed in the stable	7,440	14,880	1·48

We do not here include the corn which the horse consumes, but place that against the time which he passes out of the stable.

If, then, we take a large, or a middle sized, or a small ox, according as straw is plentiful or scarce in the country; and if we further admit that on a cold soil from 20 to 22 metzen has been sown, and on a warm dry soil from 18 to 19; and, finally, if we allow a somewhat larger quantity of dung, about 12,000 lbs. to the former, and a smaller quantity, as 9,000 lbs. to the latter, it will be easy to apply the data contained in the above table to particular fields or pieces of ground, and to the quantity of fodder which is necessary for them. But if we should wish to calculate the general average of cattle and of fodder as it is stated in this table, we shall find that one beast will produce dung enough to manure 1 19-60 acres. In the instructions and rules laid down for the estimate of the income proceeding from corn in the kingdom of Prussia, the following were taken as their basis from being most conformable to general experience:

They calculate that the produce in straw of an annual sowing will, for a fat animal, be from 1½ to 2½ acres of land of the first and second class, from 2½ to 3½

of land of the third class, and from 4 to 5 acres of land of the fourth class. But it would seem, from reference to all other data, that we are to understand by the term "large" or "great beast," small horses, oxen, and cows, when pastured.— If, therefore, we admit that the product of the first and second class land is nine bushels per acre, we shall find that we obtain

From 1¼ acres of rye, calculated at 1,935 lbs. per acre, a produce of..........	2,418	lbs. of straw.
From ¼ acre of barley, at 972 lbs. per acre..............................	1,215	"
To which must be added the hay..	1,320	"
	4,953	"

Which will make altogether about 9,906 lbs. of dung.

But if we take three acres at seven bushels of produce for the third class,

There will be on 1½ acres of autumnal corn..............................	225	lbs. of straw.
There will be on 1½ acres of spring corn................................	1,134	"
To which must be added the hay..	1,320	"
	4,711	"

Which will produce an amount of dung equal to 9,422 lbs.

According to the data on which this instruction is founded, each beast produces ten loads of manure for four horses; that is, generally, at most ten quintals to each horse. Fifteen such loads are usually considered to be requisite for every acre, if we would have the ground retain the effect of the manure during the nine years' rotation. Thus, one beast and a-half may be said to manure an acre of land.

The more carefully we compare a number of data deduced with the utmost exactitude from comprehensive averages, and relating to the produce in dung, with the fundamental principles which we have here detailed, the more shall we feel convinced that they perfectly agree with one another, and that an estimate of the quantity of dung which it is possible to obtain may be derived with much greater precision from comparison and reference to the amount of straw and fodder consumed, than it could be by any other means; and we shall, therefore, henceforward be guided by it in all our agricultural calculations and estimates.

The data with regard to the necessary quantities of fodder are as numerous as they are various. It is, sometimes, scarcely possible to believe that they can refer to the same animals. But, then, how great is the difference between a small, lean, ill-conditioned beast, that picks up a scanty living on arid fallows, in the woods, or on open commons, and another that is plentifully fed in the stable or on rich and fertile pastures! Some oxen do not yield above 200 lbs. of meat when slaughtered, while others yield 2,000 lbs. It would be absurd to pretend that these different kinds of animals receive the same kind or quality of food, or to expect that they will yield the same quantity of dung.

We have already stated the quantity of straw and fodder which, in most agricultural estimates, is generally supposed necessary for the winter feeding of cattle of various kinds, breeds, and size; it only remains for us to consider the account given by some of the authors who have treated on this subject.

De Bénékendorf allows one bushel, or 8 pounds, per day, of chopped straw of spring corn for every draught ox, and three-quarters of a bushel for a cow. It is his opinion that a piece of land sown with three bushels of barley or oats, will yield 319 bushels of chopped straw; and that, as the duration of the winter-feeding is 165 days, two oxen or cows may be kept on the produce of one sowing of three bushels of spring corn; he also thinks that the straw of rye and peas ought to be devoted entirely to sheep; that the number of cattle ought to be regulated by the quantity of straw, since the summer pasturage might be replaced by green clover given in the stable, and that, by means of crops of roots, it might be possible to do without hay.

Independent of that circumstance, a draught ox, according to him, requires 12 lbs. of hay per day, from the first of January to the first of June; a milch cow, 13 cwts. of hay in a year, besides grains, corn, and *soupe*,* or, if she is fed on

* A kind of pottage composed of grains or of cooked potatoes, and sometimes also of water mingled with meal, and poured over the chopped straw.

hay alone, 18 cwts; young or barren beasts require 4 cwts. if they are allowed other provender besides; and otherwise 11 cwts.

According to Karbe, a draught ox ought to receive a daily provender of

18 lbs. of chopped straw, 2 lbs. of straw as litter; in all, 4,800 lbs.
4 metzen of roots, or 60 bushels yearly,

during the whole of the 240 days of winter.

If roots and vegetables are scarce, or nearly all spent, 30 lbs. per day of corn, chaff, hay, chopped straw, and of litter, may be substituted. Thus an addition of, perhaps, 10 lbs. of hay, instead of roots, where the latter are altogether taken away, will amount to 2,400 lbs. per year.

A milch cow ought to be allowed 18 lbs. of straw and hay, for food, per day, during the 190 days of winter, and 2 lbs. of litter—3,800 lbs. per year; and, likewise, 4 metzen of vegetables or roots per day, or 50 bushels per year. During the 175 days of summer, a pasturage of 3 acres of clover and grass, and 2 lbs. of litter every night, or 350 lbs. per year.

An ox for fattening ought to receive in each of the 112 days, which are usually allowed for that purpose—

10 lbs. of chopped straw and } 2 lbs. of litter }	1,344 lbs. straw.
8 lbs. of hay	896 lbs.
8 or 9 metzen of vegetables or roots	60 bushels.

In my edition of "Bergen's Anleitung zur Viehzucht," I have given an account of the quantity of fodder consumed by my cows in the course of a year, at a period when all my cattle were of the heaviest breeds. It amounted to the following per head:

White cabbages	4,890 lbs.	815	lbs.	reduced to hay.
Potatoes	3,900 "	1,950	"	"
Radishes	1,830 "	343	"	"
Carrots	1,230 "	462	"	"
Green clover	14,080 "	3,129	"	"
Hay	..	1,660	"	"
Straw as fodder	..	2,312	"	"
" as litter	..	3.650	"	"
		14,321	"	"

Which produced 32,938 lbs. of dung, or very nearly sixteen loads of 2,000 lbs. each.

With such an amount of fodder, the cattle certainly ought to be completely satiated, but they did not, at any time, suffer from indigestion. In proof of this, I shall state the daily quantity of milk yielded by each of my dairy cows, which amounted, on an average, to 10 quarts of Hanoverian, or 8 quarts of Berlin measure; making 3,650 Hanoverian or 2,920 Berlin quarts per year.

These variations in the data may suffice to prove that horned cattle require little for their actual subsistence, and also that they can consume a great quantity. On the whole, an abundant supply of food is, to a certain degree, far more profitable, in the end, than any great saving or economy on this head ever can be. I have, however, ascertained, by long experience, that large-sized beasts can only be rendered profitable by being very abundantly fed. In order to establish the average quantity of food and straw on which a moderate-sized ox or cow can be most advantageously kept, I shall admit that a good milch cow or draught ox, when fed in the stall, will annually consume

In straw, for fodder and for litter	4,50C lbs.
In hay, the various kinds of green fodder being also reduced to it	4,500 lbs.

But when these beasts are pastured during the day, they have an equivalent to 4,000 lbs. of straw, and also to the quantity of roots which, if reduced to hay, would amount to 2,800 lbs.; by these means, in the former case, 18,000 lbs. or nine loads of dung will be obtained, and, in the latter, 13,600 lbs. or six loads and three-quarters.

A draught horse, when fed in the stable, requires 7,500 lbs. of gross fodder—one-third of which should be hay, and two-thirds straw, besides a sufficiency of corn.

We shall find a still greater number of variations in the accounts of the winter feeding required by sheep. In "Den Tax Prinzipien," (the principles of estimation,) we find the amount of fodder necessary for a hundred sheep, which were turned out at intervals during the winter, stated at 4,950 lbs.; and that requisite for the same flock when turned out more frequently, at 3,850 lbs. of hay. On the other hand a flock of sheep of an improved breed consumed:

	Dry Clover.	Straw and Peas.
Per 100 of Ewes	16,600 lbs.	5,500 lbs.
" Yearlings	22,000	..
" Lambs and lambkins	5,500	16,600
" Wethers	..	22,000
	44,180 lbs.	44,100 lbs.

Thus, on an average per 100 sheep, 11,025 lbs. dry clover, and 11,025 lbs. straw and peas, besides straw for litter.

In the sheep-fold of Kunersdorf, containing four hundred and sixty-six sheep, in 1804, the following amount of produce was consumed:

Hay	1,200 cwts.	Oats	7½ bushels.
Horse-beans	108 bushels.	Rape-cake	300 pieces.
Peas	46 bushels.		

Which is, indeed, an astonishing difference.

In order to determine what extent of pasturage is necessary for a cow, I shall take as a basis a table contained in Commissioner General Meyer's work, and in which all the principal items which relate to this subject are carefully defined and distinguished.

I must, however, observe, in the first place, that this table has reference to pasturages formed on fields during their period of repose, and to a small breed of cows, such as are found in the Mecklenburgh dairies.

The table relates to the meadow-pastures both in spring and in autumn. In those cases where, from the fields being laid down for pastures all the year round, three acres are sufficient for one beast, a cow is supposed to require—

	Acres.	Square perches.
From the beginning of August to the 12th of May	9	40
From the middle of August to the 12th of May	11	40
" " " 1st of May	10	60
" " September to the 12th of May	15	..
From St. Michael's to the 12th May	25	36
" " " 1st May	36	24
From St. Martin's to the 1st May	116	80
" " " 12th May	48	100

The difference between the first and the twelfth of May is indeed striking, but it is in accordance with the nature of things; because in these eleven days the vegetation is considerably more active, which accounts for the fact that the pasturing of cattle at this period is very injurious to the meadows. If the animals were continued on pasture to the 24th or to the end of May, this difference would become still more evident.

I shall also refer my readers to the same work for a table estimating the pasturage found in forests. The profit which may be derived from them, and the influence which is exercised over it by the kind and size of the trees with which these forests are filled, will all be found very accurately defined and distinguished there.

The Calenberg acre, according to which Meyer forms his calculations, is three square perches and three-quarters larger than the Berlin acre. It contains a hundred and twenty perches of sixteen feet each, but these latter are shorter than the Rhenish feet.

A great number of agriculturists are of opinion that ten sheep will consume as much winter-fodder or pasture as one cow; but this depends, in a great measure, on the nature of the pasture—for there are some kinds of mountain herbage, a certain extent of which, though quite sufficient for the keep of ten sheep, will not support one cow; while, on the contrary, there are others perfectly adapted for pasturing cattle, and are by no means suitable or profitable for sheep. In fact, the number of animals which can be kept on a certain extent of pasture depends, in a great measure, on the breed of the animals, and the purpose for

which they are designed. In those places where improved breeds of sheep are kept chiefly, if not entirely, for the quantity of wool which they may be made to produce, an extent of pasture which will generally feed a cow will barely suffice for seven sheep; while, on the other hand, an extent of pasture sufficient for fifteen sheep will afford a very poor and meagre feeding for a cow belonging to one of the large breeds. But as these differences can only be duly appreciated in certain definite localities, and by reference to the lands or the animals in question, we shall not stop to include them in our average estimates, but confine ourselves to the original one.

THE VARIOUS SYSTEMS OF CULTIVATION.

One of the most essential conditions attending every rotation of crops is that the proportion of labor and manure shall be suitable and proportionate to the extent and quality of the soil.

The well known necessity of animal manures in the cultivation of every species of vegetable products, and particularly of corn, has led all nations and all ages to consider that arable culture and grazing ought to be united, in order that each may be made to produce all the advantages which may be derived from them. There is but one opinion on this subject; but there are many disputes on the subject of their reciprocal relation to each other, and on the determination of the quantity of land which ought to be devoted to each; and particularly on the relative proportion which they ought to bear to one another, in order that the greatest possible amount of animal and vegetable products may be derived from their union.

These systems of cultivation may be divided into two classes. In agricultural undertakings regulated by the first of these principles, the chief part of the land is devoted exclusively to the cultivation of corn, or of other vegetable products, which are intended solely for the consumption of the human race; and a very small part only to the raising of food for the grazing of cattle. The meadows and fields are separated from each other; one portion of the latter is mown, and on the other portion cattle are pastured.

In the second class, the same piece of land is made to produce alternately grass or vegetables for fodder and corn; the proportion, quantity, species, &c. of the different crops, and the frequency of their repetition, or the order in which they succeed each other, being regulated by the soil, the climate, and the nature of the locality. The first class is generally designated *cultivation of grain or corn*, and the second *alternate husbandry*. We shall presently point out the various subdivisions of these two classes, and the deviations from the general rule.

These two classes are now frequently combined; for it has latterly been deemed expedient to introduce the cultivation of plants destined for fodder into those rotations, which were formerly exclusively devoted to the cultivation of corn.

CLASS 1.—*The Cultivation of Corn.*

Fields submitted to this system are appropriated solely to the cultivation of crops of various kinds of corn. We shall henceforth designate under this title the cultivation of all products destined chiefly for the wants and subsistence of mankind, and which consequently find a sure and ready sale. Where this system of cultivation is pursued, it will be necessary to have pasture grounds and natural and artificial meadows on those portions of land set apart for the purpose of feeding cattle. If these are sufficiently extensive to maintain the number of cattle which it will be necessary to keep in order to provide the requisite quantity of manure for the soil; and if these portions of land cannot be rendered more advantageous to the whole by any other means, then it may be admitted that this system attains its end, viz., that *of yielding the utmost possible amount of net produce*, and no objection can be offered against it. There certainly are instances of this case existing, but they are seldom met with, and are far more rare than most of the advocates and defenders of this system appear to believe.

This system likewise receives the names of the three, four, and five-course shift, according to the number of years which each course occupies, or which intervene between each manured fallowing. There are some rotations belonging to this class which extend to six and even to nine years; but these, as we shall presently see, can only be regarded as repetitions of the triennial rotation.

This latter is the one most frequently used, and we shall therefore begin with it; and having examined it in its primitive excellence, shall proceed to notice the additions and improvements to which it has been submitted. Afterwards we shall treat of the other rotations.

During the time of the Romans, the triennial rotation of crops, as it in all probability existed and was practised in every part of Europe except in Italy itself, where it does not seem to have been introduced until the 14th century by the Barberini, whence it derived its name, consisted in,

1. A naked fallow, with repeated plowings during summer.
2. Crop of autumnal corn.
3. Crop of spring corn.

The fallow ought always to be manured, and this invariably used to be the case when the proportion of meadows and pasture-ground to arable land was much greater than at present. At the present day, however, the fallows are only regularly manured in a very few fertile countries, or in districts where there is a great deal of rich meadow land, or perhaps where the union of stall feeding and the cultivation of plants for fodder with this system renders the procuring of manure a less difficult task. In general only every second and sometimes only every third fallow is manured, and thus the fields are only ameliorated once in six or nine years. Many farmers who have broken up their meadow and pasture-ground for the purpose of converting it into arable land, have found themselves so much reduced by the diminution of fodder and straw as to be unable to manure even a ninth part of their fields properly; and have frequently been compelled to leave a great portion of their arable land wholly untouched, or at most, able only to give it a very slight covering of manure in order to reserve the quantity necessary for those fields which are either better in quality or nearer to the buildings. This neglected part is termed exterior field or out-field land, or, according as it yields a crop of rye in three, six, or nine years, it receives the appellation of three, six, or nine year rye-land.

Where the soil is of a fertile clayey nature, and if properly cultivated, it might be classed among wheat land; and if *spelt* is also raised upon it, it is called *spelt land*.

If the land will produce ten bushels of spring and ten bushels of autumnal corn per acre, and two thousand pounds of straw from the former and one thousand from the latter, when cultivated according to the triennial succession of crops, six thousand pounds of manure, or three loads of twenty quintals each, will be obtained according to the principles stated in page 94; and as at least five such loads are requisite for a three years' manuring, there will yet be wanting two loads or four thousand pounds of manure, and these must be procured by means of hay. A supplement of two thousand pounds of this last mentioned description of fodder will therefore be requisite, or the produce of an acre and a quarter of meadow land of medium quality. Every agricultural establishment which has attained the condition to be able to furnish this quantity of manure, and which, consequently, possesses an acre and a quarter of meadow land besides the quantity of pasture land necessary for keeping the cattle in working condition during the summer, for every three acres of arable land, may support this rotation of crops without weakening itself in the slightest degree; and as, in addition to the manures above mentioned, there is also a quantity which the cattle, and more particularly the sheep, yield during the night, it follows that the fertility of the soil must be continually on the increase; so that, eventually, those kinds of grain which find the readiest sale, and yield the greatest profit, may be advantageously cultivated.

When the soil is manured only once in six years, and the produce of the spring and autumnal corn on land of medium quality amounts to seven bushels when the fallow has been manured, and to four bushels and a half when it has not received any assistance—and the produce of six years may conseqently be estimated at eleven bushels and a half of autumnal grain, and as many more of spring grain, together with 2,480 lbs. of straw from the former and 1,150 lbs. from the latter, making in all 3,630 lbs., which will yield 7,260 lbs. or 3⅗ loads of manure, while the land requires at least 5 loads of manure—2,740 lbs. will, therefore, still be wanting; to produce which it will be necessary to have 1,370 lbs. of hay. It appears, then, that the triennial rotation can be kept up and made to yield the average quantity of produce which may be expected from it, if there are seven

acres of meadow land, besides an adequate extent of pasturage to every six acres of arable land. And that, by means of these resources, and of the manure produced by the cattle, and especially by the sheep at pasture during the night, the land can be preserved from that exhaustion with which it would otherwise be threatened.

The small produce of those rotations in which the manuring takes place only once in nine years, is well known to every person, and has been already mentioned in the sections above cited.

We have supposed that the establishments in which the triennial rotation of crops is adopted, possess a sufficient quantity of pasture land; but, in reality. this is seldom the case. If, where this system is adopted, a sufficient number of cattle are kept to convert into manure the whole of the hay and straw which can be allowed them, there ought to be as many large cattle as there are acres of land to be annually manured. And it is necessary to assign from three to five acres of open pasture land, according to the quality, and from ten to fifteen acres of forest-pasture to each beast, if we would keep them in condition, and prevent their annual return of profit from being far below what it ought to be.

We may, however, deduct the pasturage which is allowed for the draught cattle from this calculation, because these animals ought, properly speaking, to be fed in the stable. Now, as it seldom happens that the disposable quantity of pasture ground is so great as here required it not unfrequently happens that, in establishments in which the triennial rotation is adopted, the horned cattle yield a very scanty return, even when every necessary care is bestowed upon them, and where they have been well-fed throughout the winter. The profit yielded by cattle is therefore almost exclusively derived from the sheep, and in such establishments even these animals are seldom supplied with sufficiently ample pasturage to enable them to yield that amount which might otherwise be expected from them. It is often necessary, as well for the sake of these animals as from want of pasturage, to defer the fallowing until the middle of the summer; a course of proceeding which is totally at variance with the essential conditions of this rotation, and which, when applied to argillaceous soils, diminishes the quantity both of the grain and of the straw produced.

The name of Schubart will be enrolled in the annals of Germany in indelible characters as one of the benefactors of the human race; although it must be admitted that he, in common with other mortals, was unable to steer wholly clear of error. He labored with indefatigable zeal to procure the abolition of the practice of letting the land lie fallow, and also of the rights of pasturage over fields as well as that of pathway; but it was not until long after his death, and after great hesitation on the part of the governments, that his wishes at length met with attention, and were adopted by Maximilian Joseph, king of Bavaria, and other princes of Germany, who, like enlightened and beneficent fathers of their people, sacrificed to them those usages which had been practised until that time for the imposition of burdensome taxes and exactions, the origin of which were mostly very equivocal.

This system of Schubart's revived the long-agitated dispute respecting the necessity or abolition of fallows, in all its original vigor, and this question appeared for some time to be more important than any other; reams of paper were consumed in the discussion of it, but no satisfactory result was attained.

As this question relates chiefly to the triennial rotation, we shall take the present opportunity of discussing it.

The principal misapprehensions, errors and disputes on this point have arisen from no precise and definite meaning having been attached to the term *fallow*. This word originally signified the state of a portion of land which during the summer, or, what was better still, during the whole year, was turned up and carefully broken and divided by means of the plow or spade, in order to prepare it, as perfectly as possible, for the reception of the ensuing crops.

Most of the Roman writers on Agriculture recommended this operation, and prescribed it as being necessary under certain circumstances; and many of them have given particular names to each of the processes which it includes. Thus they designate that act which we term breaking up by the Latin word *frangere*, the second plowing by the word *vertere*, the third by *infringere*, the fourth by *revertere*, the fifth by *refringere*, the sixth, or that immediately before the sow-

ing, by *lirare;* just as we have our particular terms by which to distinguish each of these operations.

But some persons have attached a widely different signification to the term "*fallow.*" As the fields were, either from negligence, from want of pasturage, or from a defective system of practice, and in total opposition to the aim and object of fallows, frequently suffered to remain unplowed until June, and sometimes even until August, and, nevertheless, were called fallow-fields, this word came, by degrees, to be used in a corrupt sense, and to be applied to land in a state of repose; and this introduced a misunderstanding and misconception into the discussion.

It is, therefore, necessary to restore to this word the meaning which properly belongs to it. Thus, to put in fallow, is to prepare land for the ensuing crop by repeated plowings performed during the summer, without seeking to obtain any produce whatever from it during that year. A field cannot, therefore, be said to be *fallow* until it has been plowed once, and until, in short, it has been fallowed; for, up to that time, it can only be termed a field in a *state of repose.*—When cattle are fed on it, the pasturage thus obtained is designated a pasture on a field in state of repose.

The utility of plowing fallow ground cannot possibly be overlooked or denied; and the more tenacious or argillaceous the soil may be, the greater is the advantage which will be derived from it.

A simple plowing in spring or autumn certainly will turn up and break the surface of the land, but it will not divide it sufficiently to break the clods and reduce them to loose earth. The soil, when clodded together, soon becomes hardened into compact masses, when it is covered without being broken; it even preserves the impression made upon it by the plow; and when the plowing has been performed while the ground was wet, the divided portions, exposed to the heat of the sun, become as hard as a tile. Land, when suffered to acquire this state, is highly unproductive, because the greater part of the plants having fibrous roots, are unable to penetrate these clods, and, consequently, are forced to turn round them, and the power of vegetation contained in the portion of ground which they occupy is, therefore, wholly lost. The soil might as well be composed, for the most part, of stones, as of mould thus conglomerated. There is scarcely any means by which these clods can be effectually broken, except by continued fallowing during the whole of the year—the effect of which is to bring them all successively to the surface, where they may be exposed to the action of the atmosphere; and having imbibed moisture, and become softened, they may be broken by the harrow and other implements. If this process can be continued from the end of summer to the seed-time of the following autumn, and care be taken that each operation shall be performed when the soil possesses the proper degree of humidity, the field will become transformed into an homogeneous light loose powder, and all the nutritive and fertilizing particles which it may contain will be brought into action; thus, we frequently see fields which were, to all appearance, exhausted, become exceedingly fertile after having been carefully fallowed, even though they have not received any additional supply of manure.

The second benefit which fallowing confers upon the land is the destruction of noxious weeds which have multiplied in it, either from their seeds or by the roots. These weeds, being frequently torn up by the harrow, crushed by the roller, exposed to the action of the air, and to the influence of the sun, ultimately perish, and enrich the soil by rotting upon it. As for the seeds of these weeds, they are brought to the surface by the action of the plow, detached from the clods, which frequently contain innumerable quantities of them, and placed in a position which facilitates their germination; and, at the commencement of their vegetation, the plants which have sprung from them are torn up and destroyed by the action of the plow or harrow, and contribute, by their decomposition, to the fertility of the soil. The fallow ground is thus freed from those quantities of weeds which multiply almost to infinity amongst the corn; that is to say, if the land has been broken up at an early period, and if sufficient care has been bestowed on the plowing and tillage—for the clearing of the soil from weeds depends entirely on the nicety with which these operations are performed.

In the third place, experience has taught us, and recent discoveries in chem-

istry and natural philosophy have tended to prove the fact, that even the richest land ought to be occasionally exposed to the influence of the air, if we would have it become and remain fertile; and that it derives certain particles of matter from the atmosphere, which must be combined with it in order to be transmuted into nourishment for plants. When the surface of the soil is hardened, it is as incapable of absorbing these particles of matter as the clods themselves. It is only where the soil is loose and divided that the atmospheric air can penetrate, and come in contact with all its component parts, and produce its fertilizing influence upon them. This absorption of gaseous matters takes place only at a very high degree of temperature, and appears to be most active during the warm weather of spring. The operation of fallowing is the mode best calculated to ensure to a soil all those advantages which are derived from being frequently turned up, and from its surface being often changed, and exposed to the action of the atmosphere and of light.*

Lastly, it is by fallowing that the most complete mixture and incorporation of the various constituent parts of the soil, and of the manure which has been added, can be obtained. In order that the latter may produce the full effect, it ought to be brought in contact with, and to be able to fertilize every particle of, the soil; indeed, all husbandmen are aware that the effect of manure which is placed in the ground in lumps is very trifling. There is no method by which the proper degree of admixture can be so completely effected as by fallowing; particularly when the land is also plowed and turned up several times after the dung has been placed upon it.

To all these recommendations it must be added that fallowing allows the plowing to be executed with a smaller number of cattle; because the preparation of the soil and the carrying of the manure for the fallows can be performed at a time when there is a respite from all other plowing operations. In large agricultural establishments which do not possess an extra number of teams, it is frequently a difficult matter to get the land ready for all the sowings, unless it has been prepared by fallowing; and the sowings are not unfrequently retarded, to the manifest detriment of the crops.

Thus, notwithstanding the expenses attendant on fallowing, and the temporary cessation of all return or profit occasioned by it, which is very perceptible, especially where the land is of a superior quality, the advantages that result from it are so great that, without the possession of some extraordinary means of tillage, it is impossible to dispense with it in any of those rotations in which the corn harvests frequently succeed each other.

Where attempts have been made to dispense with fallows on the well-manured lands in the neighborhood of towns, the ground has become filled with weeds, and, notwithstanding the favorable appearance of the corn during spring, it yielded a very scanty crop of grain; so great, indeed, were the inconveniences resulting from this system of cultivation, that one fallowing was insufficient for correcting the defects which the soil had contracted, and it was often found necessary to lay it down to grass for some years, or to expend a great quantity of manure upon it, and then devote it to the raising of crops of various kinds of fodder for cattle, until, after receiving certain preparatory tillage, it can be again sown with grain.

The only thing which will enable us to dispense with fallows, and with those periods of repose which we lately mentioned, is an exceedingly careful tillage—such, for example, as that which the Belgians bestow upon their land, by arranging and dividing the surface of it in narrow beds or strips, after having, in the first place, pulverized it by the action of the plow, the harrow, the roller, and other agricultural instruments; by sowing the tops of the ridges only, and leav-

* The description here given by the author, of the process of fallowing land when properly executed, shows that he fully comprehended the meaning of the word in the proper sense; and he very justly reprobates the imperfect performance, as being the main cause of having brought a discredit on the process. The concluding observation on the mixture and incorporation of the constituent parts of soils and manures, as forming one great advantage derived from fallowing, is highly scientific, practical, and most valuable, and of which the benefits are yet forthcoming; for the very best and most improved practice of our day has not yet reached that point, though clearly demonstrated by observation and experience, and also by natural and chemical science. Clods of soil and lumps of manure, as the author very judiciously remarks, exert little influence on each other; the reciprocal action of affinity is not produced from want of comminution and commixture, so as to expose to mutual influence the greatest possible surface of particles. Delta grounds and alluvial soils, and experience in every cursory trial, fully confirm the truth and value of the theory.

ing the sides exposed to the influence of the atmosphere, and by the cultivation of various kinds of plants, and by weeding and hoeing them with the hand—which, although not a general practice in triennial rotations, is very frequently introduced, and often with very material benefit.

It is not so necessary to repeat the operation of fallowing every third year, as was formerly supposed; the land may often be maintained in better condition by being employed in the cultivation of vegetables destined for the feeding of cattle, which will be the means of producing a greater quantity of manure than if it were fallowed every third year. But this mode of proceeding requires very great care and attention, more extensive power and facilities at command for working the land, and a period of time of sufficient length between the harvest and seed-time to allow a very careful tillage being bestowed on the soil. Fallow crops are certainly far more efficacious than naked fallows, when, as is the case in some districts, these latter are not commenced until after the middle of the summer. Hence the late barley, which frequently is not sown until the middle of June, is to be recommended for such rotations, notwithstanding the uncertainty of the success. If land which is to be completely fallowed, is very carefully plowed at least four times during warm and dry weather, it ought to continue clean and fertile, and free from weeds; and the farmer has a right to expect crops of clover, leguminous plants, or other fallow crops, on the next fallowing, if not on the two succeeding fallowings.

The considerations just mentioned have given rise to the compound triennial rotations, or, more properly speaking, to the six, nine, and twelve year rotations, which many farmers and agriculturists are in the regular habit of pursuing.—These systems comprise the following courses of crops:

1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Peas and clover. 5. Autumnal corn. 6. Spring corn.

Or: 1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Clover. 5. Autumnal corn. 6. Spring corn. 7. Peas. 8. Autumnal corn. 9. Spring corn.

Or: 1. Fallow. 2. Autumnal corn. 3. Spring corn. 4. Clover. 5. Autumnal corn. 6. Spring corn. 7. Fallow. 8. Autumnal corn. 9. Spring corn.—10. Peas. 11. Autumnal corn. 12. Spring corn.

It is seldom, however, that we meet with intelligent and observing agriculturists who strictly adhere to these rotations; they either sow their land with clover, or reserve it for leguminous crops, or suffer it to lie fallow, according to the state of it at the time the barley is sown, or according as it is more or less light or free from weeds. They choose the clearest part of the land for clover and peas, and do not restrict themselves to a systematic course of crops, but are guided by circumstances—making it a rule to sow clover in the same place only once in nine years, experience having proved that it does not succeed if repeated oftener. When it happens, after having sown leguminous plants, either from unfavorable weather or from their having over-rated the fertility of the soil, they do not obtain a sufficiently abundant crop to cover the ground with its leaves, they either have it eaten off the ground while in a green state by cattle, or bury it with the plow and lay down the land for a naked fallow.

Although the pure triennial rotation leaves one-third, or very nearly that proportion, of the cultivated ground unemployed, it has, nevertheless, been frequently represented as the best, and, indeed, as the only good system of cultivation that can exist, and for the following reasons:

1. From the excellence of this system being proved by its universality and antiquity; it being incredible that a defective system should have received the approval of all nations and all ages, and have been able to extend and maintain its ground so generally.

2. From no system, hitherto known or discovered, producing so great an amount of grain. From corn being the principal food of man, the most necessary kind of produce, and, consequently, that for which there is the greatest demand, and the production of which is most profitably and equally repaid. From the fact of this system yielding a smaller amount of animal produce being, in itself, a strong proof of the great utility, since land will yield three times as much nourishment for the human species in vegetable produce as in animal food.—From being thus equally advantageous and profitable to society, to the State, and to the farmer.

3. From labor being more equally divided in this system than in any other.—From its allowing more time between the spring and autumnal sowings for tilling the fallow ground and carting the manure. From its being thus possible to get the land ready early enough for the sowing of the autumnal corn, the crop of which is the richest and the most important; and, consequently, from being possible to work out this system with a smaller number of teams.

4. From all the agricultural operations appertaining to this system being simple and requiring little skill; and from being, consequently, possible to execute them by means of ordinary laborers. From their likewise requiring the most simple instruments, and those which are best known and in most common use.

5. From this system being founded on an already established division of land; from the fact that all the laws, regulations and customs relating to Agriculture, and all its external privileges and liabilities being closely linked with this system, which cannot in itself be altered without annihilating all these institutions.

But all these considerations vanish when tested by the following facts:—The antiquity and universality of this system admits of no dispute. It has come down to us from the Romans, who introduced it into their remotest provinces, and especially into those from which they derived their corn; but in the environs of Rome, and in some of the most populous districts of Italy, they adopted a similar system of tillage to that used in gardens, and an alternate rotation which was much more advantageous. The Roman ecclesiastics, by whom most of the arts and sciences, and Agriculture in particular, was disseminated among the barbarous nations, pointed out to them this system as being the most advantageous.—These people still possessed a superabundance of land, although it was no longer possible to till those uncultivated and undivided lands, or keep and graze their flocks over them, as they had previously done.

In the capitular of Charlemagne, *de villis et curtis Imperatoris*, the triennial division is positively dictated to his officers and stewards. It is not, therefore, at all astonishing that, in an age when authority predominated over every other consideration, and the understanding ventured not to oppose, but blindly submitted to every regal or positive enactment, that the triennial rotation should have become so prevalent throughout Christendom, and that laws and ordinances, whether relating to property, or to agricultural affairs, or to rural policy, should have been based upon it.

It is, likewise, natural enough that no change should have been made in this system during the dark and troubled times which followed, when Agriculture was entirely carried on by a class of peasantry, men buried in the depths of slavery and ignorance, or under the inspection of the lowest grade of freemen. Those institutions and practices which custom had sanctioned swayed the arts and sciences, for a considerable lapse of time, with irresistible power; and any one who ventured to express the slightest doubt of their conformity with the laws of reason was regarded as little short of a heretic. It is only of late years that any thing like discussion on the virtues or defects of this system has arisen; and it was only on some portions of land in the Netherlands, Holstein, and in some counties in England, where any other system of cultivation had been adopted.—This observation is sufficient to show how slight is the support which the triennial system derives from antiquity and universality.

Changes in the succession of crops in the triennial rotation have, however, already been frequently made with the general consent of proprietors, even of portions of land on which a common right of pasturage was exercised. I know several villages in which the fields are thus cultivated:—1. Fallow. 2. Barley. 3. Peas. 4. Rye. 5. Oats. 6. Rye. And then the land is fallowed again; or it is manured for the following succession:—1. Barley. 2. Rye. 3. Fallow. 4. Rye. 5. Peas. 6. Barley. 7. Rye. 8. Oats. 9. Fallow.

Where the soil is very strong, it is scarcely considered safe to sow wheat upon manured fallow ground, from fear of the crop falling down. It is, therefore, more usual to sow barley, which, according to the general opinion in these parts, is less exposed to this accident than wheat. But, against all these reasons, the triennial system still maintains its ground, and has its supporters.

In some places the quadrennial system of cultivation has already been introduced and practised for many years on the common or parish lands. The following is, then, the order or succession of crops after the fallowing:—1. Autum-

nal corn. 2. Spring corn. 3. Autumnal and spring corn or peas, and then another fallow. This last selection is as contrary to all the rules of Agriculture as can possibly be imagined. Peas, when properly cultivated, are an excellent preparation for a corn crop; and, after bearing them, there is not the slightest occasion for the land to lie fallow.

Many land-owners have adopted on their own farms, and prescribed to their tenants, a sort of quadrennial rotation, from which they anticipate very great advantages. This system, which appears to me to be founded on a misconception of the English quadrennial alternate rotation, comprises, first, a year of clover crops, independent of the one allowed for the fallow crops; and then crops of corn in succession; which are to be followed by clover on the fourth year. The clover, as might have been expected, was much less successful under this rotation than under the triennial rotation. On lands thus divided, it is now customary to raise three successive crops of corn, and then to let the ground lie fallow. I know but one single instance of an estate on which, for the last five-and-twenty years, the English course of rotation, viz.—1. Weeded crops; 2. Barley; 3. Clover; 4. Autumnal grain—has been strictly followed. I have already said that the above-mentioned system is based on a misconception of the latter; in fact, it was introduced about that period when Frederic the Great, perceiving the advantages of the English system, caused it to be introduced upon his estates under the superintendence of an Englishman named Brown, and other experienced agriculturists whom he had sent to study in England; and he also endeavored to introduce it throughout his dominions by assisting such landed proprietors and farmers as were disposed to entertain his views.

On some estates bordering on villages, we meet with a division into five parts or allotments, with great variation in the succession of the crops. As:—1. Autumnal corn. 2. Peas. 3. Autumnal corn. 4. Spring crop. This system of rotation is not faulty, provided always that the fallowing is complete and carefully executed. These quadrennial and quinquennial rotations might be much more easily converted into a good system of cultivation than the triennial, because in them the cultivation of plants for fodder occupies the proper place.

The summary of all the modes of tillage, which I shall give in a tabular form at the end of this section, will throw additional light upon the relation which the triennial rotation bears to itself and to other systems of cultivation, as well with respect to labor and manure as to the absolute produce.

*Alternate Cultivation—Alternate Rotations with Pasturage.**

This species of cultivation, in which the land is devoted for several successive years to the growth of corn, and then for some others to the pasturage of cattle, or occasionally to crops of fodder for these animals, has been for a considerable period designated, by the English, Germans, and Italians, by the title of alternate cultivation, an appellation which is peculiarly appropriate to it. That which I have here designated "alternate cultivation and pasturage," comprises those rotations in which, after a certain number of years, the land is sown with grass seeds, or left to produce a spontaneous herbage for two or more years, when cattle are pastured on it. In Germany, this system of cultivation is generally called *koppel wirthschaft* (enclosure cultivation), even though the lands subjected to it may not be enclosed. For our own part, we shall reserve the term "enclosure" exclusively for land surrounded by hedges, applying the term "*sole F. Schlag G.*" (crop division) to each of those partitions which are made according to the rotations of crops, whether consisting of one separate and distinct piece or comprehending several, or only a portion of some more extensive division. According, therefore, to our acceptation of the term, the crop divisions are portions of land appropriated to certain successions of crops; and after the lapse of a certain number of years, or the term which the rotation lasts, each portion returns to the same state as at the commencement of the course. We shall not take the trouble to consider whether or not they are surrounded by hedges or fences, or even whether all the parts are united in the same place; a condition which is by no means essential, especially for stall-feeding, in which, under cer-

* In order to distinguish the subdivisions of this system in the north of Germany, the author gives the name of the "Holstein system" to that in which the years of pasturage predominate, and of the "Mecklenberg system" to that in which there are the greatest number of corn crops and fallows.

tain circumstances, diversity of position may be rather beneficial than otherwise.

The chief recommendation of tillage alternating with pasture, appears to me to be a circumstance which all the detractors of this system have passed over in utter silence; namely, that these rotations embrace the whole extent of the arable land; those portions only which are too wet and which cannot be drained, or which are too hilly, or which are, perhaps, too far distant, are left unplowed; the former are reserved for meadow, and the latter for forest land, and each is devoted exclusively to that particular purpose.

To this advantage must be added the increase in the profit derived from the cattle, arising from an abundant supply of food throughout the whole summer, and from the greater number of cattle which the extent and the richness of the herbage crops enables the farmer to maintain. Thus, then, even supposing that the produce in grain should not be at all increased, the increase in the profit of the cattle only, which no person can deny or doubt, would be quite sufficient to decide the question in favor of alternate cultivation and pasture.

The inhabitants of Holstein, that is to say, the greater number of them, for there are some few agricultural establishments there which are regulated according to the Mecklenberg system—the inhabitants of Holstein, I say, employ a greater number of crop-divisions and a longer rotation. They generally cultivate several successive crops of grain, and then lay the land down to grass, and leave it in a state of repose for a much longer period. The usual proportion in Holstein is, one-fifth autumnal corn, one-fifth spring corn, and three-fifths pasturage. If the land is fallowed, which is usually done since the practice of marling has been generally introduced, there is only one-tenth of the land fallowed. In that case the rotation is as follows:—1. Oats on the broken-up pasture-ground. 2. Fallow. 3. Autumnal corn. 4. Spring corn. 5. Autumnal and spring corn. 6, 7, 8, 9, and 10. Pasturage.

There are seldom or never less than ten divisions, and we sometimes find the rotations extending over twelve, thirteen, and fourteen years, in which the years of corn crops and those of pasturage succeed each other without alternating, but with a far greater proportion of the latter, for they never cultivate more than five successive corn crops.*

The following are the rotations usually adopted in Mecklenberg:—

The rotation of six years.—This comprises one complete fallowing, three successive corn crops, and two years of pasturage. It is peculiarly adapted to estates which possess rich meadows and fertile pasture grounds. It requires a great deal of manure, either on account of the extent of the fallowing, which occurs every six years, or because two years of repose are not sufficient to restore to the soil that degree of fertility which it has lost by bearing three crops of grain. Whenever it has been practised on estates of only moderate fertility, it has invariably led to disadvantageous results, arising from the quantity of grain produced and the consequent exhaustion of the soil.†

The septennial rotation comprises one fallowing, three successive crops of corn, and three years of pasturage. This system is the one most in repute in the present day, because three years of pasturage allows the soil a sufficient term of repose, and the grass is most abundant in the third year; in consequence of this latter circumstance, the fallow can be much more efficiently manured than under the preceding rotation, and thus the soil gains the full portion of nourishment requisite for the production of three successive crops of grain. It certainly does not require less manure than the following one; nevertheless, it cannot be kept up without some accessory meadows. Latterly, some persons have attempted to introduce a fourth crop of grain; but if they do not possess rich pasturage, or separate lands for the growth of fodder, an injurious exhaustion must be the result, unless, indeed, very great discernment be exercised in the selection of the

* The time that land can profitably remain in pasturage under the alternate system of cultivation, depends wholly on the quality of the soil. Good lands will produce a grateful herbage for many years, and even improve by lying at rest, while inferior soils will not hold good grasses above two or three years, and hence the necessity of renovation. Whenever a quantity of vegetable matter, less or more, has been profitably accumulated by the herbage, an opportunity is presented of deriving benefit from the action on future crops. From this circumstance the superiority of the system arises.

† The six years course of cropping and others following it, here mentioned, differs from the alternate rotations in Britain in having three or more grain crops in succession before grasses are sown, and without intermixture of the grain crops with the esculent and herbaceous plants, and, consequently, is wanting in the general benefits.

crops. We shall speak of this system more at large elsewhere; at present it is only our wish to give a mere sketch of those which are in common use in Mecklenberg.

The rotation of eight years usually comprises one fallowing, four crops of grain, and three years of pasturage. It requires richer manure for the four crops of grain; and this can only be obtained from a larger supply of hay, because the quantity of straw progressively diminishes during the third and fourth crops. On estates which require to be improved after having been exhausted by cropping, this rotation is frequently made to include three crops of grain and four years' pasturage; and the same system is occasonally established upon exterior divisions which possess a moderate degree of fertility.

The rotation of nine years usually comprises one fallowing, four crops of grain, and four years of pasturage. There being only one fallowing in this rotation, and that occurring only once in nine years, the effect of it is less sensible than in any other. Besides, land which enjoys five years repose has much less need of manure, and therefore a smaller extent of meadow land is sufficient. It is true that this system provides little fodder for the winter maintenance of the cattle that graze during the summer over this wide extent of pasturage. Some agriculturists have made this rotation yield five successive crops of grain, and allowed only three years of repose and pasturage; but this course can only be supported on those lands which are exceedingly fertile, and such a system appears to us to evince rather a spirit of avarice and of covetousness than of economy.

The rotation of nine years with two fallowings, which was formerly so much in vogue, is now seldom or never to be met with; it was, however, productive of very fine crops of corn on tenacious soils which require a great deal of tillage.

It is only on the exterior divisions of estates where we meet with a rotation which embraces six years of pasturage, three corn crops, and one fallowing.

The rotation of ten years, comprising two fallowings, four crops of corn (the first two of which are separated from the last two by these fallowings), and four years of pasturage, is now only met with on a very limited number of estates. The smallest possible extent of meadow land is, however, quite sufficient to maintain the fertility of land cultivated according to this system. In my opinion, it is peculiarly adapted to a complete course of crops. If five successive crops of corn are raised upon land subject to the rotation of ten years, as has been sometimes attempted, the destruction of the soil, and, consequently, that of the rotation, is greatly precipitated.

The rotation of eleven years.—This yields two crops of grain after the first fallow, which, in the majority of cases, is not manured; in three years afterwards comes the second fallow, which is manured; consequently, there are four years of pasturage. This rotation was formerly preferred by the agriculturists of Mecklenberg to all others, and there are still many persons who do not repent of having adhered to it.

In good argillaceous land, where the deficiency of manure is compensated by repose and fallowing, this rotation may be made to yield sufficient nourishment for the cattle, and may be supported without much manure, and, consequently, with a very small extent of meadow land.

The rotation of twelve years, which yields three crops of grain after each fallowing, may, as far as the proportions are concerned, be compared with the rotation of six years; if it yields as much manure as the latter, a small portion of it may be taken from the first fallow, and the second will receive a more abundant supply. It seems to me to be superior to the rotation of six years, and for this reason, that the manure is saved where it would not be necessary, and where it might cause the corn to be laid, and is applied to the land in larger quantities wherever there is need of it.

If only one fallowing can be manured, that is to say, if the land can only be manured once in twelve years, the quantity of corn obtained will be very small in proportion to the extent of the sowings, and yet the soil will be sensibly impoverished.

With a very few exceptions, the general succession of crops of cereal plants which are raised is—autumnal corn only after the fallow; then two, three, and sometimes four crops of spring corn, the first of which is usually barley, and the

others oats. But few vegetables are usually cultivated; when peas are sown, it is generally on the last field. When cultivated in that place, it cannot be expected that the produce will be very encouraging. The culture of other leguminous plants is still more rarely introduced.

In Mecklenberg it has not been found advantageous to allow the land to bear grass more than four successive years; the pasturage begins to diminish in the fourth year, and after that term the ground becomes covered with moss, and the cattle derive a very scanty subsistence from it. This is occasioned less by the difference which exists between the soils and climates of Holstein and Mecklenberg, than by the greater degree of impoverishment of the fields when they are laid down to pasture.

They seem to be entirely ignorant in that country of the method pointed out by Camillo Tarello, namely, that of not burying the dung until the last sowing, or of even spreading it over the new turf; in fact, the adoption of this plan, according to which the manure is only applied to the soil as a kind of capital, is perhaps considered to produce too great a diminution in the corn harvests, although the loss in that point will, in the end, be thoroughly compensated by the increased richness of the pasturage, and by the abundance of the produce which will be obtained when the ground is cultivated again.

Latterly the practice of sowing white clover with the last crop has become very general: only a few apathetic and indolent agriculturists, or men who are firmly wedded to old opinions and customs, neglect this practice, and consider natural herbage to be quite as efficient and beneficial for the nourishment of cattle; but cow-keepers and dairy farmers are, almost invariably, great advocates of this practice, and their opinion ought to possess some weight.

It makes a very great difference in the pasturage of the first year, and the effects are even sometimes perceptible on that of the second and third. The produce of the pasturage ought to be valued both according to the nature of the soil and the greater or less disposition which it shows towards the bearing of grass, as well as according to the period which has elapsed since it has been without cultivation.

The testimony of a great many aged persons goes to prove that a wide extent of land, which had been wholly exhausted by the triennial rotation, has become so much ameliorated by this system of cultivation in the course of one generation, that it is now capable of producing a considerable surplus of corn for exportation, besides affording an abundant pasturage to three times as many cattle as were formerly fed upon it. This is so striking a proof of the superiority of the system over any other, that it has awakened the attention of all the provinces in the north of Germany, and has gained for it a great number of proselytes wherever the ancient laws and ordinances with respect to property do not restrict the free exercise of the will, and where the estates are sufficiently extensive to admit those great changes which can only be made gradually, and, during the first years, with a sacrifice both of money and of produce.

The following are the principal advantages of the system of alternate cultivation and pasturage: It saves a great deal of labor, and that which is applied to it is always more profitable than that which is applied to the triennial rotation, in which land that has not been manured is too often plowed in vain, since it gains little more than the equivalent of as much more as the seed. The operations succeed each other in regular succession, being the same every year and also equally divided among the different seasons. Each plowing can be performed at the period which is most proper for it; and as the time at which the land ought to be broken up occurs about autumn, it is easy to choose the most favorable periods for plowing and harrowing. It is a common saying, that if any one wishes to see land carefully and perfectly fallowed, he must travel through Mecklenberg. The manure is applied to the soil at the most suitable time, and it is carefully mingled with the upper layer in order that the action on the crops may be direct and complete as possible. Every thing is in readiness for the autumnal sowing, so that the first favorable moment which occurs may be embraced for putting the seed into the ground; a circumstance which has considerable influence on the success of the crop, and the other rotations do not possess the same advantage.

The diminution in the amount of labor has been made a matter of reproach

to this system. It is said to be detrimental to general industry, and calculated to diminish the population. But this complaint can only be made by those who do not consider or recollect that under this system no one portion of the land is suffered to lie uncultivated, but that it embraces the whole extent of the domain, deriving from each portion that kind of produce for which it is best calculated. If the population of Mecklenberg has diminished since it was first introduced, which certainly is not the case, that result could only have been attributed to the great extent of the estates, and to the scarcity or total want of small farms.

Besides the regularity in the quantity and nature of the agricultural labors in this system, the crops will, if we except extraordinary years, be found to be always similar, and that not only with respect to extent of ground, but of the absolute produce; at any rate, the difference in the production of certain years is not so sensibly felt in this system as in many others. The autumnal corn seldom or never turns out badly, because it is sown early and at a proper period. Unless any unforeseen accident occur, the amount of the products may generally be reckoned with tolerable accuracy. It is for this reason that those excessively abundant crops, which no one can account for, are seldom obtained from any portion of the fields, and the certain and regular net produce which may be expected from the estate can be calculated with a much greater degree of certainty than under any other system.

In proportion as a judicious distribution of the lands, and a permanent introduction of this system of cultivation, require knowledge, intelligence and skill, in like proportion will be the facility with which it can be carried on when it is once fairly established. Very extensive agricultural undertakings may be put in train by these means, and kept in good condition by a very trifling amount of surveillance. Everything has its proper course, and all the operations succeed one another in their fitting times and places. There is nothing to be attended to but the ordinary routine of the operations of plowing, harrowing, sowing, reaping, mowing, and gathering in the crops; and these details are so well understood, and, in general, so well executed, that every upper laborer, bailiff, or over-looker, even if he can neither read or write, is perfectly capable of conducting and directing them.

The cattle which are kept for profit or income are usually farmed out, and it is the business of the dairy-farmer to look after them; and his interests lead him to pay particular attention to the meadow land, and to raising crops of fodder.—In summer these cattle have their regular pasture-grounds, and in the winter they consume all the hay and straw which the draught cattle do not want. Even if the year has been otherwise unfavorable, and the fodder has been rather scanty, the farmer need not trouble himself about anything else while he is sure that the animals will not want for actual necessities. The cow-keeper, in contracting for the farming out of his cattle, always takes care to stipulate that, come what may, they shall have a sufficient if not a plentiful supply of food.

It is very evident that, with this regular course of cultivation and this equality of products, the profit derived from agricultural industry can never be very considerable. An estate produces a certain income; which latter is, on an average, almost equal to the net produce of the cultivation. An estate which is completely arranged, and which does not possess any peculiar or undiscovered resources, may be safely purchased; but if the same course of cultivation be continued on it, it will be impossible to make it yield more than the amount of the rent, unless, indeed, some extraordinary combinations of circumstances raise the price of corn considerably beyond the natural value.

I do not mean to infer that a skillful and reflective man may not, by means of judicious and well-directed ameliorations, find opportunities of materially improving many estates, and deriving considerable advantages from them. But this is quite distinct from cultivation, properly so called, and can only be carried into effect in certain localities. Although a great number of experiments of this nature have been made with variable results, and although it is evident that they cannot always be attended with success, yet there, doubtless, are numerous resources yet undiscovered on estates at present submitted to this species of cultivation.

The regularity with which the agricultural operations appertaining to this system are performed is so great that, by means of it, any person may easily direct

several separate estates at the same time, without the necessity of having a skillful overlooker for each. It is sufficient occasionally to see that the machinery continues to work, and to accelerate the motion at times when it appears necessary. The book-keeping is very simple, clear, and concise. In Mecklenberg there are many farmers renting large estates, who keep their whole accounts on their door-posts with a piece of chalk.

Besides that the work is distributed in a more uniform manner under this system than under any other, it is also much less in amount. This is one reason that the rotation is so well adapted for those situations or districts in which there is a scarcity of laborers, and, especially, where it is difficult and often impossible to engage supernumeraries in the hour of need. Every year it employs the same number of laborers and of draught cattle; and if the services of the persons whom it employs at one period are not required at another, they at least know what to expect, and will take care to seek some other occupation during the intervals of labor.

In less cultivated and less populous countries, where estates comprising large extents of land, often of little or no value, render the *great culture* incontrovertibly preferable to the *small*, this system will be found far more convenient and advantageous than any other. It has this merit, that at any period it may be totally changed; that it forms an excellent precursor to any other rotation; and that it also prepares for an advantageous division of large estates, since any peculiar cultivation may easily be introduced on any portion of ground lying at rest.

In Holstein the produce from the cultivation of grain is too small, and not proportionate to the nutrition and succulent juices contained in the soil. In Mecklenberg, on the other hand, the defect that exists in cattle economy does not belong so much to the number of animals, but arises from a want of sufficient nourishment for them in summer as well as in winter. The results of this defect are, not only the absence of a satisfactory profit from this branch of rural economy, but, what is still worse, a scarcity of manure, which, if the cultivation were ever so good, would alone be sufficient to prevent the crops from being so fine and so abundant as they might be if the soil were properly manured.

Besides, under these two methods of cultivation, the produce, both in grain and in straw, is greatly diminished by the circumstance of three, four, and sometimes more crops of corn succeeding each other without interruption; and, although the Mecklenberg farmer may, after the fallowing on which he bestows so much care and labor, obtain as fine a crop of autumnal corn as the quality of the soil will enable it to bear, yet the other crops, and particularly the third and fourth, are so poor and scanty that, in general, they are thought to produce well when they yield from four to four and a-half times the amount of the seed. If a more judicious choice of crops was introduced into these two systems, there is not the least doubt that the land would yield a much greater profit both in vegetable and animal products; and this change might be carried into effect, as it has been by several agriculturists, without the necessity of making any sensible alteration in the established division, or of introducing the practice of stall-feeding, which seems to be attended, as yet, by so many difficulties.

In order to demonstrate the suitableness of these changes as clearly as possible, and also to point out what ought to be their nature, we will here endeavor to give a precise idea of one of the most essential parts of agricultural science, viz. the manner in which the crops should be made to alternate; this subject, however, ought, properly speaking, to be included in the remarks on cultivation and on the propagation of vegetables.

On the Succession of Crops.

Even during the most remote periods, it was remarked, by attentive observers of field and garden tillage, that the soil produced incomparably finer crops when these were constantly varied, and when two of the same kind were not suffered to succeed each other in the same place; and that, according to the nature and condition of the soil, one series of crops proved more advantageous than another. Whenever the cultivation was confined to one plant, or to plants of one particular species, it was always judged necessary that the soil, after having produced a certain number of crops, should be left in repose; that is to say, it should be allowed time to reproduce and collect the succulent matters which were proper

for the nourishment of the crops it had to bear. Manure and cultivation certainly tend to facilitate and advance this action, but Nature requires time also in which to collect and renovate her exhausted energies. The gardener, who frequently changes the nature and species of his crops, certainty is not obliged to have recourse to repose; but the mere farmer, whose only aim is to raise corn, must, unless he manures his land extravagantly, allow it a certain period of rest. In those places where the improvements in Agriculture have raised the price of land, it is easy to see that this increase of price does not proceed from any difference in the laws of Nature as applied to the soil of fields and gardens, but only from the farmer having learned to manage his cultivation so as to be able to produce, alternately, all the crops which he requires. The ancients founded their Agriculture on the lessons of experience, and they raised it to such perfection as to be able frequently to make the same land yield two crops in one year. The Romans were well aware of the beneficial effects of careful tillage, and exposure to the influences of the atmosphere, on land that was destined to bear only wheat, barley and oats, or other grain of this kind; but they also know that

Mutatis quoque requiescent fructibus arva,
Nec nulla interea est inaratæ gratia terræ.*

Hence arose the following question:—"Which are the crops which can be made to succeed one another with the greatest advantage, and which are those that have the tendency of preparing the soil for the one which is to follow?"—This problem is the more difficult of solution because experience affords us so many contradictory answers, which, however, without doubt arise from the variations which exist in the soils and climates of different localities and countries. From the very earliest periods of natural history, attempts have been made to resolve this question in a theoretical manner, either by analogy or by inference, or both; and this second problem has been put forward:—"What if each different kind or species of plant requires some elements of nutrition peculiar to itself, and from which alone it can derive the requisite degree of nourishment; and what if it be impossible that it can succeed on any soil which does not contain these elements?" The careful examination of numerous facts and experiments ought to lead us to answer this question in the following manner:—It is a well known fact that each plant does not require peculiar elements for its nutrition, but that its own organs digest and assimilate to it those juices which they extract from all those component parts of the soil which are destined for the nutrition of plants in general. Vegetables whose properties are the most opposite—plants the most corrosive and venomous, as well as those which are most beautiful and useful—those the most opposite in variety and contradictory in nature—will be found growing on the same soil and flourishing together—a thing which never could occur if they required different nutritive matters for their support. In short, all varieties of plants, and all their various parts and juices, are composed of the same substances—a fact which has only lately been discovered. The constituent parts of all organic substances are carbon, oxygen and hydrogen, with which a small portion of azote is generally united, but very few of them contain any great quantity of this latter element; plants also contain earth and potass, and some few contain phosphorus and sulphur. These constituent parts are to be met with in every fertile soil, even if they are not imbibed directly from the atmosphere. By means of the functions and operations of their different organs, the plants assimilate these matters to their own substance, and form all those various combinations of them which are found in the infinite variety of vegetable products. From these facts the erroneous inference has been deduced, that a soil which contains all the requisite elements for the nutrition of one plant ought necessarily to have in it those that are proper and suitable to others, and that the fertility of a soil is produced merely by the physical contexture.

But theory alone is quite sufficient clearly to demonstrate the truth of the contrary opinion; namely, that the plants contain and combine these substances in very different degrees. It is possible that the roots or suckers of all kinds of plants possess a sensibility and a power of choice, which enables them to imbibe and appropriate to themselves the exact proportion of each of these substances

* Your fields would repose equally as well if you changed the crops, and then you would not have to pay the rent of land which bore no crop.

which Nature leads them to require for their support. But, in order that they may succeed in accomplishing this purpose, it is necessary that they should be enabled to meet with the proper proportions and combinations of these substances within their own immediate sphere. If this proportion does not exist, or if some of these substances are present, but not in sufficient quantity or in that degree of combination which the plant requires, then its growth will be slower, and it will not thrive so well. In a soil which, although not entirely without some one of these substances, yet does not contain a sufficient quantity of it, the plant must put forth its roots in every direction, to seek and absorb that which is absolutely necessary for its nourishment. It is not improbable that the soil may contain too great a proportion of some one of these necessary substances, and that the plant being thus suffocated by the superabundance of it, and the scarcity or total absence of all the others, may fall from weakness and not thrive.

This reasoning clearly explains the fact that a succession of crops of the same nature always falls gradually off, and become less and less productive, if cultivated in the same place, even when the soil contains all the component parts usually considered necessary for their nutriment; and also the reason of the fact that they regain their perfection so soon as the soil has been suffered to repose, and are made to produce some other crops, and of an ameliorating nature. It is easy to suppose that a plant which absorbs a diametrically opposite proportion of elementary substances to that which is required by another, will tend to establish the proportion which is best adapted to the latter, and will cause it to thrive far better than it would have done if the soil had not received this preparation, and had been deprived of some of its nutritive qualities. A soil may be completely exhausted by means of this alternation of crops; so much so, indeed, as to be incapable of affording nutriment to any plant; but it is exhausted much sooner if one particular species only is cultivated on it. (Einhof, "Annal of Agriculture of Lower Saxony," vol. viii. p. 321.)

If various kinds of plants vegetate on one soil at the same time, there can be no doubt that they will yield much less than they would do if cultivated separately and singly; for, without taking into consideration the space both above and below the surface of which they deprive each other, one must absorb some portion of those substances which are necessary to the support of vegetable life in general, and, consequently, the others are deprived of it.

But let us return to the data afforded us by experience: here we find that all skillful gardeners, and many farmers, are agreed upon one point—namely, that it is advantageous to cultivate some plants together; that far more abundant crops of them are thus obtained than would be the case if they were cultivated separately and on distinct portions of land.

In places where the art of gardening is carried to the greatest perfection, five or six different kinds of products may frequently be found growing on the same bed; and according to the unanimous assertion of all skillful gardeners, an assertion which is founded on experience, this proceeding is attended by a considerable saving both of soil, manure and labor.

In many countries this system has been applied to the cultivation of fields and of arable lands, and these intermixtures of crops have been raised with various degrees of success.

Any kind of vegetable, as beans, peas, or vetches, if sown in conjunction with some kinds of grain, spring rye, barley, or oats, will yield a far more abundant crop than if the two were sown separately. It has long been known that leguminous plants when sown among corn on a soil which is so arid that they could not have vegetated alone, will yield well without sensibly diminishing the corn crop. Thus, according to the experience of the majority of agriculturists, wheat intermingled with rye may succeed on land which cannot be made to bear wheat alone; and when sown in this way the wheat crops are finer than they would be in places where they can be cultivated without any other grain. This admixture also succeeds when it is sown on wheat stubble, where every one knows from experience that wheat will not thrive alone, even when the soil is otherwise perfectly adapted for its growth.

Experience likewise confirms this hypothesis, that by means of an intermediate crop of some other nature, that true proportion of the elementary substances which is suitable to one particular species of grain may be reëstablished. We

have just now stated that wheat sown on wheat stubble never succeeds. Wheat sown after barley does not thrive well, unless the soil was so excessively rich that it needed this preliminary crop to render it suitable to the wheat. Rye sown after rye succeeds better, but even then the produce in grain is considerably diminished.

But if a crop of some of those plants belonging to the class *diadelphia*, as peas, vetches, beans, or clover, be interposed, then the second crop of the cereal plants will turn out well; and if the leguminous plants are cut while green, or if the second cutting of the clover is plowed in, there is every probability that the second crop of grain will surpass the first. The truth of this principle has been so clearly demonstrated by experience, and is so well known to every attentive observer, that I shall refrain from adducing any farther examples or entering at greater length into the subject, and the more especially as I must return to it when I come to treat of the cultivation of each plant separately.

The cultivation of gardens sufficiently proves that when the soil has lost the power of reproducing one species of vegetable, it is not exhausted, but may be made to bear others with success. Beds of earth, after having produced several crops of one kind of plant, lose every faculty necessary for its reproduction, and cannot be made to bear it again until they have been exposed for several years to the fertilizing influences of the atmosphere, and impregnated with fresh manure; but they are still capable of bearing French beans, lettuces, and other vegetables. Sweet-scented and ornamental flowers, as violets, &c. require that the earth contained in the pots in which they grow should be frequently renewed, even although it may seem to contain an abundance of nutrition; the florist never sows the same kind of flowers twice in one place, neither ought young fruit trees ever to be planted in the same spots where others of the same kind have stood. In nursery grounds it is an invariable rule that the soil shall be changed at each renewal.

Herr Einhof and myself have frequently prepared some experiments which might enable us to determine the nature and degree of the changes which the mould undergoes in a soil in which one plant has been cultivated, until every element necessary for its reproduction is exhausted. But we have always been interrupted and thrown out in these experiments, which, from having to be made in the open air, are attended with very great difficulties, and present obstacles which nothing but the most uninterrupted attention can overcome. In fact, there is no known means of guarding against those various accidents which, in one moment, will destroy the work of years and leave no satisfactory result behind. In order to succeed, the experimentalist ought to possess a garden enclosed with the most scrupulous care, devoted solely to his own purposes, and from which it was possible to exclude both birds and insects.

It has generally been observed, that if any crop fails or yields a scanty produce, not from impoverishment or any other defect in the soil, but merely from some accidental cause, the same kind of plant will, if sown in the same place in the following year, succeed far better than it would otherwise have done. Again, a crop which succeeds one which formed a good preparation for it will thrive and yield the more abundantly in proportion as the former was productive; such, for example, is the case where wheat is sown after clover or beans. The more abundant the produce which a plant yields, the greater will be the degree of exhaustion of the soil which has produced it, if the same plant is sown on it again; but such will not be case if it is succeeded by a crop of another kind, and there are many instances in which an abundance in the first crop has proved rather favorable than otherwise to the successor.

That which appears to exhaust land most is the formation of grain, seeds, and other farinaceous substances. All herbaceous plants, therefore, if cut in their green state and taken off the ground at the time of flowering, and of the most vigorous vegetation, will absorb little or no part of the nutritive juices contained in the soil, but on the contrary, they seem in some respects to ameliorate it: this is a truth of which every day affords new proofs to those who will bestow the pains of attentively considering the works of Nature. It has not yet been decided whether a plant does or does not absorb a greater quantity of nutritive matter, and particularly of carbon, from the soil during the period which the grain takes to ripen; but it is well known that during that period all the mucilage and juices secreted in the stalk and root, are yielded up to the grain, and the former become

converted into mere filamentous substances. It is not, however, a matter of indifference whether the root and stubble which remains in the ground has preserved the vitality and nutriment, or whether it is dry when the stock is detached from it; because, when the former is the case, the nutriment contained in those parts of the plant which still remain attached to the soil, is still farther augmented by the carbonic acid gas which the stubble absorbs and communicates to the earth, and, consequently, the soil is more ameliorated. In the cultivation of spergula, as an intermediate crop, it has frequently been remarked that the roots have this effect. If this plant is mowed while green, it ameliorates the soil very considerably; some persons pretend that if it is pulled up, as is sometimes the case, the exhaustive powers are in equal proportion. This is, perhaps, the cause of the exhausting effects which are attributed to a crop of flax. These facts are so well attested, that it is not worth while to consider all those doubts which contradictory spirits have raised with regard to this matter.

However, I shall not permit myself to carry out this theory so far as some persons when they positively assert that the soil is not deprived of any portion of fertility and nutritive power by those productions, the vegetation of which is arrested before the formation of the seed has commenced. All kinds of tuberculous plants collect within their root or bulb, a store of alimentary juices for the nourishment of their shoots in the following year; these roots form a species of magazine from which these biennial plants derive the nutrition which is necessary for the production of their flowers and shoots in the ensuing spring. Both experience and trials have tended to prove that if these roots are left to decay in the soil, the effect on it is exceedingly beneficial. If they are gathered, they certainly subtract some portion of the nutrition contained in the soil; although, on the other hand, they mechanically ameliorate it by means of the cultivation bestowed upon them, and thus form an excellent preparation for other crops. When vegetables of this kind leave their roots, stalks, and some portion of their leaves in the ground, they restore to it a part of that nutriment which they have absorbed during the process of their vegetation.*

* The theory of the rotation of crops is of so much interest to the agriculturist, that we shall make no apology for repeating in this place what we have elsewhere had occasion to remark ("Farmers' Encyclopædia"):—

"When cattle," says Davy, "are fed upon land not benefited by their manure, the effect is always an exhaustion of the soil. This is particularly the case where carrying horses are kept on estates; they consume the pasture during the night, and drop the greatest part of their manure during their labor in the day-time. The exportation of corn from a country, unless some articles capable of becoming manure are introduced in compensation, must ultimately tend to exhaust the soil. Some of the spots, now desert sands in northern Africa and Asia Minor, were anciently fertile; Sicily was the granary of Italy, and the quantity of corn carried off from it by the Romans is, probably, a chief cause of its present sterility."

The same theory is also supported by M. Liebig. In his excellent work on "Organic Chemistry," p. 158, he remarks: "It is evident that two plants growing beside each other, will mutually injure one another, if they withdraw the same food from the soil. Hence, it is not surprising that the *Matricaria Chamomilla* and *Spartium Scoparium* impede the growth of corn, when it is considered that both yield from 7 to 7·43 per cent. of ashes which contain 6-10ths of carbonate of potash. The darnel and the *Erigeron acre* blossom and bear fruit at the same time as the corn; so that when growing mingled with it, they will partake of the component parts of the soil, and in proportion to the vigor of their growth that of the corn must decrease, for what one receives the others are deprived of. Plants will, on the contrary, thrive beside each other, either when the substances necessary for their growth, which they extract from the soil, are of different kinds, or when they themselves are not in the same stages of development at the same time. On a soil, for example, which contains potash, both wheat and tobacco may be reared in succession, because the latter plant does not require phosphates, salts which are invariably present in wheat, but requires only alkalies and food containing nitrogen. According to the analysis of Posselt and Reimann, 10,000 parts of the leaves of the tobacco plant contain 16 parts of phosphate of lime, 8·8 parts of silica, and no magnesia; whilst an equal quantity of wheat straw contains 47·3 parts, and the same quantity of the grain of wheat 99·45 parts of phosphates."

The late George Sinclair took a similar view of the cause of the exhaustion of soils. "If," he says, "a plant impoverishes a soil in proportion to the weight of vegetable matter it produces on a given space of ground, the following will be the order in which the under-mentioned plants exhaust the ground, being the proportion they bear to each other with respect to weight of produce:

Mangel Wurzel	25	Kohl-rabi (bulb-stalked cabbage)	14
Cabbages	25	Swedish Turnip	13
White Turnip	16	Carrots	11
Potatoes	15		

But when we take the weight of nutritive matter which a plant affords from a given space of ground, the results are very different, and will be found to agree with the daily experience in the garden and the farm.

The following figures represent the proportion in which they stand to each other with respect to the weight of nutritive matter per acre, and in exhausting the land:

Potatoes	63	Kohl-rabi	17
Cabbages	42	Swedish Turnip	16
Mangel Wurzel	28	Common Turnip	14
Carrots	24		

Change of crops also prevents very materially the increase of the predatory grub and insects which also

Independent of their chemical qualities, the long cylindrical roots of these plants produce a mechanical effect which is extremely beneficial to tenacious and argillaceous soils. Deprived of life, and yet not decomposed, they have the same effect as small pipes, keeping the soil loose and friable, and enabling the atmospheric air to penetrate into all the interstices. They loosen the soil as much as repeated plowings would do; and after a crop of these roots, it will only require to be plowed once before the seed is sown in it.

General experience thus seems to prove what has long been my firm opinion, that even if we do not admit that these vegetables require a different proportion of alimentary substances, they will not, when allowed to reach maturity and to bear seeds and flowers, take from the soil much more than they bestow on it in other ways. But if they are cut while green and before the seeds have begun to form, it cannot be denied that they materially enrich the soil and render it capable of bearing crops which it could not previously have supported.

Although those vegetables which are comprised under the denomination of weeded plants deprive the soil of some portion of its nutritive power, and render it necessary to manure more abundantly in order to remedy this defect than would have been requisite if it had been submitted to the operations attendant on a naked fallow; nevertheless, by means of the cultivation which is bestowed on them, if proper implements for the purpose are used, they will form a very advantageous substitute for a fallow, and will tend to loosen the soil, expose it to the fertilizing influences of the air, and effect an intermixture of the various constituent parts with considerably less labor than than could be done in any other way. If the farmer chooses to have them dug up, a portion of the inferior layer of the ground will be brought to the surface, and the destruction of the weeds will be thus effected. All these things may, with judicious management, be equally as well attained by the cultivation of these roots as by fallowing the land; and the additional amount of food which these crops provide for the cattle, and the consequent increased quantity of dung yielded by the animals, will more than compensate for the extra manure they require. And if, as is customary in England, the cattle intended for fattening are made to eat them on the ground, the amelioration thus retained is fully equivalent to a complete manuring. When the English speak of long rotations without manuring, there are always plants of this kind interposed between the corn crops. Although this mode of proceeding appears to savor more of stinginess than real economy, it is not without its advantages, as the cattle thus fattened most certainly pay the rent of the land and the expenses of the labor, if they do not yield some farther profit; whereas a fallow, so far from yielding any profit, costs a considerable sum.

Those root-crops which belong particularly to this class of economical plants have this peculiarity: they form a better preparation for barley than fallow, but they do not form a good preparation for autumnal corn. This may arise, in a great measure, from their having a tendency to retard the seed-time. Several crops of grain may be raised in the same rotation without the addition of fresh manure, if one crop of leguminous plants be interposed between two of corn.

If, however, vegetables are cultivated instead of these roots, and are carefully tilled with the horse-hoe, the autumnal corn will succeed equally as well after a crop of beans, especially on argillaceous ground, as it would after a fallow, and, in the opinion of many persons, much better. Thus in Kent, where so great a quantity of wheat is cultivated, beans sown in rows are considered as the best preparation which the ground can receive. Many vegetables which yield advantageous produce and particularly cabbages, if transplanted or sown in rows, may be substituted, if a sufficient quantity of manure can be procured, and if there is a superabundance of fodder.

In order effectually to destroy weeds, it is of importance that the various kinds of grain should be sown alternately; because some of the cereal plants favor the growth of noxious weeds far more than others. This is a very important subject

more or less prey upon the farmer's crops. The parent of the wire-worm, for instance, which is the larva of a small beetle, the *Elator segetis*, may be seen in the summer months, depositing its eggs on lays or meadows abounding with the cereal grasses; for instinct teaches it to place its eggs where the young wire-worm will meet with its natural food, which are the cereal grasses. Change of crops, therefore, not only checks the deposit of the eggs, but by removing the natural food of the young vermin, it materially prevents increase, or even their continuance; which otherwise, as is the case, for instance, with the wire-worm, might for four or five years be a pest to the soil.

of consideration before making choice of a rotation for any piece of ground, and especially if it is infested with weeds, as by means of a judicious selection of crops the land may sometimes be completely cleared.

These facts and motives form the rules by which we ought to be governed in our choice of the crops which are to form a rotation; but, while arranging this matter, the cattle, and the fodder requisite for their sustenance, must not be lost sight of, and ought to be considered under two points of view: first, with regard to the profit which may be derived immediately from them; and secondly, to the advantage which may be derived from the manure which they produce.

Those rules which lead us to select certain alternations of crops do not, as some persons have supposed, require that half the fields shall be exclusively devoted to the cultivation of plants for fodder. There are many places even in England where the alternate succession of crops has been practised from time immemorial, and where, so far from cultivating vegetables for fodder, they even sell the straw at the market towns, and keep few, if any, cattle, because the marine and aquatic plants thrown on the coast and mixed with mud and slime, collected with great care, furnish them with an abundance of manure. The inhabitants of these places principally cultivate and alternate crops of podded plants with the cereals, a portion of which they send to the London market.

But, at any rate, these rules require the most judicious care and management; they mostly need that a large portion of the fields shall be devoted to the cultivation of fodder for cattle, because the abundance or scarcity of the manure which they will produce depends entirely on the nature and quantity of the fodder which they receive; and the manure again, in its turn, exercises a powerful influence on the crop of grain. It will sometimes be found that great and durable advantages arise from the choice of a rotation, in which one-half, two-fifths, three-eighths, or four-sevenths of the whole is devoted to the production of plants for fodder; while, in other cases, one-fourth, one-fifth, or one-sixth part will be found to be quite sufficient, and all the rest of the land may be appropriated to the growth of products destined for sale, and alternated in the proper manner.

However evident the propriety of such a proceeding may have been, very few persons ever thought of modifying the quadrennial rotation; and, instead of sowing first autumnal corn, then spring corn, and then peas, to sow first autumnal corn, then peas, and then spring corn, and then fallow. But those agriculturists who have pursued this course find that it answers exceedingly well, as they obtain an additional quantity both of grain and straw. Many German agriculturists, and especially Eckart, in his "Experimental Economy," have approached very near to this practice; but in the present day many persons are so blinded by prejudice that they cannot see the most palpable objects, or rather that they obstinately shut their eyes to every thing which appears to be in contradiction to their preconceived opinions.

Woellner and Germershausen also advocate this rotation of crops. But though almost every farmer well knows that the grain crops are improved by being varied and separated by others of a different kind, and no one refuses his assent to this opinion as a theory, yet how very few, if any, can be brought to renounce the old triennial rotation. The greater number of adherents are certainly prevented from leaving it by laws which compel them to follow this established system; but there are many proprietors, both of small and extensive estates, who have the liberty of cultivating their lands according to their own discretion.

For my own part, accident and necessity, and not the perusal of any publication on English Agriculture, or any reflection on the subject, led me to adopt this alternate, perfectionated system of cultivation. As I have been honored with the title of the father of this system in Germany, I trust I may here be permitted to relate the circumstances which induced me to adopt it. I was an ardent disciple of Schubart's system of clover and stall feeding, and consequently wished to introduce that plant into my rotation, and to cultivate it during the third year instead of fallowing the ground. But it did not succeed; the field became infested with weeds; the autumnal corn which I sowed, after a single plowing, completely failed, although I manured the land after plowing the clover, and it had been already manured in the previous winter. With the assistance of a tolerable field of lucerne and green oats, I obtained sufficient green food to keep my cattle during the summer, but in the winter I felt the want of the fodder I had

expected to derive from my field of clover; all that I had to give them was some potatoes and turnips, grown on the lucerne field after it was broken up, and a small quantity of natural hay. Filled with gratitude to these two vegetables for the valuable assistance they afforded me, I had a portion of that land on which the clover had failed broken up and planted with potatoes. The crop yielded by the roots was abundant, but late; and as the weather proved wet and unpropitious, I was not able to sow rye on this ground, as had originally been my intention. I therefore sowed barley on it the following spring; and, as I was fully determined to have a supply of clover, I sowed the seeds of it thickly with the barley. The following year I had some good clover for the first time; while another field which had been manured during the winter, and on which the clover had been sown after a second crop of grain, produced very little besides sorrel. After yielding a miserable cutting, this last-mentioned field was plowed three times previous to being sown with rye; while the former was plowed only once after having yielded a second cutting of clover, and yet it produced a decidedly finer crop of rye than the other; and these circumstances had the effect of determining my choice of a rotation.

Nevertheless, I was far from attaching any value to it beyond that of peculiar adaptation to my own circumstances and situation. On the contrary, I felt some degree of shame at the idea of becoming a disciple of the system advocated by Pfeifer, Meyer, Schubart, and Gugemus—a mere grower of potatoes and an imitator of all the petty gardeners in my neighborhood who cultivated their acre of ground, all, as nearly as possible, in the same manner. However, when I came to consult and converse with them, I found that their experience coincided entirely with my own. I made only one difference, namely, the introduction of a hoe from Mecklenberg, for the purpose of bringing the mould round the roots of my potatoes, and which has now come into general use throughout Germany.

It was not until some time afterwards that chance threw in my way the works of some of those English authors who regarded this rotation, or a similar one, as the only basis of good cultivation; who advise that the fallow should be replaced by crops planted in rows, and carefully tilled; and consider clover to be only an ameliorating crop when, sown with the first crop of grain, it finds the soil thoroughly loosened and cleaned by the fallow crops, and, consequently, vegetates so thickly and luxuriantly as to cover the whole surface of the ground with a shade; and who, when this is the case, regard the cultivation of this plant as an excellent preparation for wheat; but who would deem it a transgression of all the principles of good Agriculture to sow wheat on any place where the clover had turned out badly, at least until that spot has been allowed to rest for a time, or been cleaned by a summer fallow. I thought it my duty to make this system known to the German public, and also some English experiments, which I learned were made about the same time, and which seemed to coincide with my own views. I accordingly published it, first in the Hanoverian Magazine, and subsequently in my "Introduction to a Knowledge of English Agriculture."

It is not, therefore, entirely without reason that this rotation has been designated the *English system*, although it is not in general use even there, but is only practised in some particular counties, and on the estates of some few enlightened agriculturists, whence it will doubtless become every year more and more diffused.

The following are the principal advantages of this system of cultivation:—

1. The abolition of the dead fallow; in the place of which, after a certain number of years, plants are cultivated either as fodder for cattle or for sale, which, during their vegetation, admit light plowings, or tillage with the hoe or horse-rake being applied between the rows both lengthwise and across, by which means the soil obtains as much benefit as it would receive from a fallow. There certainly may be some fields which will require a dead fallow at the commencement of this rotation; but that operation having once been thoroughly performed, they never ought to need a repetition of it. The principal amelioration ought to be bestowed on this first division; every particle of manure which can be spared should be devoted to it, and the quantity bestowed ought to exceed that which would be proper for any other species of crops; indeed, it is almost impossible

that these crops can be too plentifully manured. This manure tends to divide the soil and also to destroy all the germs of weeds which are contained in it.

2. These weeded crops ought to be succeeded by spring corn—first, because it is usually so late before they are removed that there is not time left to sow autumnal corn; and secondly, because, in general, experience teaches us that the former yields a much finer crop than the latter, especially on argillaceous land, and also leaves the soil in sufficient condition to bear a succeeding crop of autumnal corn. This spring corn may be wheat, oats, or barley; the latter is most usually sown, and especially a species of rice barley, or two-rowed barley, or barley without skin, (*Hordeum celeste nudum.*) Should the soil, either from not having been sufficiently cultivated, or in consequence of a very wet summer, not have been properly cleaned and divided, we must, in this particular case, give the preference to the small or four-rowed barley, because it allows time for the plowings to be repeated before the sowing takes place. But, in general, these plowings are so wholly unnecessary that the spring sowings require little preparation besides that which may be given with the extirpator or harrow, which, in this season, when there is usually such a press of labor, is a very great advantage.

Many persons fear that the spring cereal plants will be laid if they are sown on so rich a soil; but experience ought to reässure them such will never be the case, if they will only take care not to sow the seed too thick—a practice which is at once superfluous and highly injurious. Deep plowing will always prevent the corn from being laid.

3. The following fundamental rule must not be lost sight of, namely, that two crops of grain should never be allowed to succeed each other, but that they should always be separated by an intervening crop at least, unless it occurs at the end of the rotation, when the fallow crops are to succeed, and the products cannot be so much injured by the grounds being hardened and infested with weeds.

The farmer must be guided in the selection of these intervening crops by the number of the divisions of land, and by the wants of the establishment. They may be composed of clover, vegetables, oleaginous plants, and, in short, of any kind which does not belong to the gramineous class.

4. It is absolutely necessary that clover should be sown on a good soil, which has been well tilled and thoroughly manured. It is usually sown with the crop which succeeds the weeded plants. Where this is the case, there is no reason to fear the success, provided it is sown in a proper manner: the roots then penetrate so far into the soil, which has been deeply loosened, that it has little to fear from the inclemency of winter; and the old saying with regard to clover, doubtless founded on experience, that the soil becomes tired of it, is not applicable here, since the experiments of twenty years may be adduced to prove that, although it should be sown in the same place every fourth year, it will flourish better in each successive crop.

5. In rotations of longer duration, in which the agriculturist endeavors to obtain the utmost possible quantity of manure and of fodder, and to bring the soil into the highest possible degree of fertility of which it is capable, it will be found very advantageous between two crops to raise one which shall not be suffered to arrive at maturity, but is mown while green for the purpose of feeding the cattle. Vetches and buckwheat are best adapted for this purpose, as the stubble leaves the land thoroughly prepared for the reception of the autumnal corn. By means of products of this nature, it is possible to obtain, in the same year,

Double crops. With this system of cultivation there is no doubt that it would be possible to obtain double crops on several divisions at once; but in the climate of the north of Germany, and on extensive farms which cannot command a sufficiency either of laborers or of teams, it is not so easy a matter as at first sight it may appear to be.

Crops of roots sown on the plowed stubble of autumnal corn certainly do sometimes succeed very well in this country; but, in order to obtain a crop, they must be sown very quickly, and in the midst of all the numerous labors that attend the period of harvest. I cannot, from my own experience, offer an opinion with regard to the practice, recently so much vaunted, of sowing carrots in the spring among the autumnal crop of rye; and I cannot discover any trace of the existence of such a practice among the English, who are generally endeavoring to multiply their crops as much as possible. I am perfectly well aware that it is by no

means difficult to obtain a second crop in a field of beans or maize, planted in rows, and cultivated with the horse-hoe; and roots may be advantageously sown between the rows of these plants, when all the operations belonging to their cultivation have been performed. A field of vetches will produce, first, vetches to be mown while green; then black wheat, which may also be mown while green, and which is, in general, perfectly successful; or turnips, which may be sown equally as soon, and which will fully repay the expenses of their cultivation: sometimes vetches are sown twice in close succession, for the purpose of being mown while green.

7. If in a long rotation it is found necessary to manure the land twice, the second amelioration is never applied to a crop of grain, but to one of some other kind; and then the preference is always given to a crop which may be mown while green, because the vegetation will never be so great, and the weeds which germinate and vegetate amongst it will never materially injure the crop. The plowing which is bestowed on the ground immediately after the removal of this crop, mixes and incorporates the manure with the soil, and the former is thus deprived of that degree of fermenting warmth which tends so much to accelerate the vegetation of young wheat plants, and too often to lay them.

8. This system of cultivation does not require that one-half of the fields shall be devoted to the purpose of raising fodder for cattle; but, as must be evident from what has already been said, merely that one-half of divisions shall be devoted to the production of grain crops. The farmer is perfectly at liberty to cultivate all or any kind of products for sale on the remaining portions; and, provided he has a sufficiency of manure, there is nothing to prevent him from cultivating those plants or vegetables which are likely to prove most profitable. But, in order to secure that abundance of manure which, when combined with skillful cultivation, is capable of producing such astonishing effects, it is frequently necessary that the farmer should content himself, during the first rotation, with a small portion of saleable products, in order to raise a store of future provender for his cattle.

By means of this alternation of crops, the farmer has it in his power either to pasture his cattle on a portion of the fields, or to feed them entirely in the stable. In the former case, the rotation with pasturage is brought to its highest degree of perfection; and the latter affords undeniable advantages in those positions and circumstances which render stall-feeding difficult. The highest possible degree of produce can only be obtained from the soil by means of this system; but it is doubtful whether the highest amount of profit is thus obtained from the labor which is applied and the capital which is invested.

We will next proceed to examine the system of

Alternate Cultivation, accompanied by a suitable Succession of Crops and Pasturage.

In this mode of cultivation, one portion of the land is laid down as pasture for cattle, and sometimes for sheep only. But the soil is used for this purpose while in very good condition; and, in order that it may produce the desired effect, it is sown with the seeds of those plants which are best fitted for pasturage; and thus it is made to yield a very rich and abundant herbage, which is capable of either maintaining a greater number of cattle, or of feeding those which are kept on a smaller space. Besides this advantage, other kinds of fodder are likewise cultivated, either for the purpose of feeding a few or all the cattle in the stalls during the summer, or of feeding them conjointly in the stalls and on the pastures, so that it may never be necessary to turn the animals on the pastures too early in the spring, or to overstock them.

This system of cultivation is never profitable unless the rotation comprehends at least eight years. If the cultivation of grain be not much restricted, and if one division is set aside for the growth of fodder, the land does not bear herbage for a sufficient length of time to allow the realization of all the advantages which might be expected to be derived from it. Excepting in small farms, on which stall-feeding is always more profitable than pasturage, I would alter the period allowed for the rotation from six or seven to twelve or fourteen years, which numbers would render the transition far from difficult.

Eight is the smallest number of divisions which I consider to be suitable to

this species of cultivation; and I should recommend the following rotations (this mark ** will denote the times when it will be necessary to bestow a complete amelioration, and this one * will mark the period when a moderate manuring will be sufficient):

1.**	*a* Beans sown in lines	or *b** Potatoes.
2.	*a* Autumnal corn	*b* Spring grain.
3.	*a* Clover for mowing	*b* Clover for mowing.
4.	*a* Spring grains	*b* Autumnal corn.
5.*	*a* Peas	*b** Vetches.
6.	*a* Autumnal grain	*b* Autumnal soil.
7. and 8.	Pasturage, with white clover and grasses.	

1.	Oats on the broken up pasture	or *b*** Potatoes.
2.**	*a* Beans in lines	*b* Spring corn.
3.	*a* Autumnal corn	*b** Peas.
4.*	*a* Vetches	*b* Autumnal corn.
5.	*a* Spring corn.	
6.	*a* Clover for mowing.	
7.	Pasturage.	

In nine-crop divisions:

1. Oats on the broken pasturage.
2.** Weeded crops sown in lines.
3. Barley.
4. Clover.
5. Autumnal corn.
6.* Peas and vetches.
7. Autumnal corn.
8., 9. Pasturage sown with grasses.

Or:

1. Oats on the broken up pasturage.
2.** Weeded crops.
3. Barley.
4.* Peas and vetches.
5. Autumnal corn.
6. Clover for mowing.
7., 8., 9. Pasturage.

In ten-crop divisions:

1. Oats on the broken up pasturage.
2.** Weeded crops.
3. Barley.
4. Clover for mowing.
5. Autumnal corn.
6.* Peas and vetches.
7. Autumnal corn.
8., 9., 10. Gramineous plants sown for pasturage.

Should the farmer wish to have more clover and less pasturage, he can allow the former to remain for two years, and deduct one year from the period allotted to pasturage.

Or the rotation may be thus arranged:

1.** Cabbages and peas.
2. Autumnal corn.
3.* Weeded crops.
4. Barley.
5. Clover.
6. Autumnal corn.
7. Spring corn.
8., 9., 10. Pasturage.

Or, if the soil is of a sandy nature, it may be thus arranged:

1. Black wheat.
2. Rye.
3.** Weeded crops
4. Oats.
5. Spurvey.
6. Rye.
7., 8., 9., 10. Pasturage.

In eleven divisions:

1. Oats.
2.** Weeded crops
3. Barley.
4. Clover.
5. Autumnal corn.
6. Vetches to be mown while green.
7.** Cabbages.
8. Autumnal corn.
9., 10., 11. Pasturage.

Cabbage should never be cultivated unless there is a plentiful supply of manure. Whenever this is not the case, the vetches must be succeeded by a crop of autumnal corn, and four years devoted to pasturage.

Or, the rotation may be arranged as follows:

1.** Cabbage.
2. Autumnal corn.
3.* Weeded crops.
4. Barley.
5. Clover.
6. Autumnal corn.
7.* Peas and vetches.
8. Autumnal and spring corn.
9., 10. Pasturage.
11. Pasturage until the middle of summer.

When divided into twelve years:

1. Vetches.	7.* Peas.
2. Autumnal corn.	8. Autumnal corn.
3. Clover for mowing.	9. Pasturage.
4. Oats.	10. Pasturage.
5.** Weeded crops.	11. Pasturage.
6. Barley.	12. Pasturage.

In this rotation, likewise, the pasturage in the twelfth year may be broken up about the middle of summer; cabbages may also be substituted for vetches in No. 1, if there is a sufficiency of manure.

Or:

1. Vetches.	7. Beans weeded.
2. Autumnal corn.	8. Oats.
3.** Weeded crops.	9. Clover for mowing.
4. Barley.	10. Pasturage.
5. Peas.	11. Pasturage.
6. Autumnal corn.	12. Pasturage.

When there are fourteen divisions:

1.** Cabbages.	8. Clover.
2. Autumnal corn.	9. Autumnal corn.
3. Peas.	10. Oats.
4. Autumnal corn.	11. Pasturage.
5.** Weeded crops.	12. Pasturage.
6. Barley.	13. Pasturage.
7. Clover.	14. Pasturage.

Or, the rotation may proceed thus:

1. Oats.	8. Barley.
2.** Weeded crops.	9.** Beans weeded.
3. Barley.	10. Wheat.
4. Clover.	11. Pasturage.
5. Clover.	12. Pasturage.
6. Autumnal corn.	13. Pasturage.
7. Peas.	14. Pasturage.

Rotations comprising a greater number of years may be considered merely as repetitions of those already mentioned, and only attended with various modifications. I shall only subjoin a rotation of twenty-four years, which has actually been introduced on an estate on which three dairies and the fields appertaining to them are contiguous, so that these are all included in one whole; this rotation is practised on an extent of 3,000 acres, and is as follows:

1.** Cabbages.	14.** Beans weeded.
2. Autumnal corn.	15. Autumnal corn.
3.* Potatoes.	16. Clover for mowing.
4. Barley.	17. Autumnal corn.
5. Clover for mowing.	18. Vetches for mowing, and then roots.
6. Do. do.	19. Spring corn.
7. Autumnal corn.	20. Peas.
8.* Peas and vetches.	21. Autumnal corn.
9. Autumnal corn.	22. Clover for pasturage
10. Pasturage.	23. Pasturage.
11. Pasturage.	24. Pasturage of spring to be broken up early, in order to allow time for planting cabbages.
12. Pasturage.	
13. Oats.	

If, in this rotation, it should be necessary to fallow the ground completely or to manure it with marl, it should be done as much as possible on those divisions which are least in use, and even then some kind of product may be derived from the soil both in spring and in autumn; as, for example, a crop of vetches, to be mown while green, or a crop of radishes.

The rotation of which we are about to speak is peculiarly adapted for keeping large flocks of sheep, to which the pasturage is devoted, while the cattle are for the most part fed in the stalls.

Alternate Cultivation—with Stall-Feeding of the Cattle.

The following is one of the distinguishing characteristics of this system of cultivation: the cattle are fed all the year round on fodder, cut expressly for that purpose, and are never turned out to pasture except towards the end of the summer. They are fed in stalls, or in courts or yards constructed for the purpose, or

in strong moveable enclosures, the situation of which is changed every year, and placed near to those divisions of land which are intended to furnish the principal part of the fodder. In some points of view, the practice so much esteemed in some countries may be comprehended under this head—namely, giving the cattle a good feed in the stable before they are turned out to pasture.

This is not the place for entering into any arguments relative to the advantages of the one of these systems over the other; all that we have to do at present is to consider the relation in which they stand to cultivation in general.

The following are some of the principal advantages attendant on this species of cultivation:

1. The same, or even a larger, number of cattle can be maintained on the produce of a much smaller extent of ground.

(*a*) Because, under this system, the fields receive a preparation which fits them for the production of those vegetables which are used as fodder. Nor is the propagation of herbage left to Nature alone: the farmer sows and plants the seeds of those plants which are best adapted for the nourishment of cattle, and which are most likely to succeed in the soil which is destined to receive them. By this means the generative powers of Nature are brought into full action, and the soil is made to produce an incomparably greater quantity of fodder than could be obtained from it under any other course of cultivation.

(*b*) Because this species of cultivation allows the plants destined for herbage to attain their highest state of vegetation, and to reach that point of development at which they yield the utmost amount of produce of which they are capable, both as regards quantity and quality. In fact, the development and growth of most of the plants destined for fodder progressively increases to a certain point, and this increase is greater in proportion as they approach the highest degree of perfection which they can attain: in the early part of their existence, the vegetation is very weak for a time, but, as the plant becomes more and more developed, the vegetation is accelerated; but when, as is the case on pasture lands, they are not suffered to attain their full maturity, the utmost amount of produce cannot be derived from them. The plant, however, ceases to grow as soon as it has flowered; and, in proportion as the seed is developed, the stalk and leaves lose some part of the nutritive juices which they previously contained. It is, therefore, evident that it is only by mowing that they can be made to yield the highest advantages, as, when this is performed at the proper season, the plant, not having been weakened by the formation of seeds, will frequently put forth new shoots, which, if allowed to remain, may attain an equal degree of perfection.

(*c*) Because, in this system, the plants are not crushed, destroyed, and trodden down, or their vegetation retarded by the pressure of the feet of the cattle.

Experience proves that by this method one-half of a given extent of land may be made to yield an equally abundant and rich provender as that which, under other circumstances, would be derived from the whole; and thus one-half will be left at liberty to be applied to any other purpose, and yet an equal, if not a larger, number of animals may be profitably kept.

2. Cattle are kept principally for the dung which they yield, and it is only under this system that it is possible to collect and obtain the utmost quantity of manure.

In every system of cultivation wherein the cattle are fed on the pastures, the principal part of the dung voided by them during the summer is scattered abroad. Those excrements which fall on the herbage are totally lost for all purposes of cultivation, and they appear to afford but little benefit to those spots on which they fall; for the dung which is voided over old pasture grounds, on which cattle constantly graze, does not appear to augment the vegetation of the herbage in an equal proportion. It frequently produces no other effect on the plants on which it falls than giving it a disagreeable taste, which disgusts the cattle; and the knowledge of this fact frequently leads the herdsmen to collect the lumps, and appropriate them to their own use. The loss is not so great where the dung is voided over fields laid down to rest; but even then the principal part of it is evaporated, and the land does not derive one-tenth part of the advantage which would accrue to it if the same quantity of manure was carefully collected, prepared, and properly mingled with the soil.

3. In cultivation combined with stall-feeding of cattle, it is much easier to make crops of fodder and of grain succeed each other alternately, than under any other system; and, therefore, all the numerous advantages that attend this union and alternation of products are better attained. It admits those plants which are destined for fodder to be cultivated in such an order and succession as shall offer the least possible degree of interruption to the succession of crops destined for sale, and particularly to the corn crops; and as the former are a preparation for the latter, and are principally intended to clean the soil, and render it loose and fertile, they render the operation of fallowing altogether superfluous, and form a very advantageous substitute.

4. This system likewise furnishes the cattle with a regular and abundant supply of succulent and agreeable food all the year round, provided the proportion and succession of the fodder crops is properly regulated. Consequently, the health and strength of the animals is preserved and sustained, and they are thus rendered more capable of work, and made to yield a higher amount of profit. When cattle are fed on pastures, this will never be the case, unless the herbage is uncommonly rich and abundant, on account of the inequality which is frequently found to exist in the fertility of pastures in different years, whether distant or successive.

Where stall-feeding is practised, the excess of fodder which the cattle do not consume in one year may be reserved for some other season which is less fertile; besides, it is very beneficial to the cattle to have dry food mingled with their green meat.

By means of this system, therefore, it is not only possible always to feed the cattle regularly, but also to preserve a steady equilibrium in all the other parts of the rural economy; since not only an average quantity of manure may be reckoned upon every year, but the farmer may likewise consider that, when he has a superabundance of fodder, he can always increase the number of his live stock, if he thinks proper, or deems that such a course will tend to augment either his profits or the quantity of manure likely to be derived.

5. Lastly, it has not only been proved, by the results of innumerable experiments, that cattle can be maintained in perfect health by means of stall-feeding, especially if occasionally, when they are taken out to water or to bathe, they are allowed some exercise in the open air, but also that they are thus preserved from several very dangerous diseases to which animals that are depastured are liable, such as inflammation of the spleen, &c.; and that they are far less disposed to catch infectious diseases: so much, indeed, is this the case, that, in some countries where this system of feeding is generally established, it seldom happens that any disease spreads very far. At any rate, it is evident that, at such a period, this mode of feeding has decided advantages over the grazing of cattle in open fields or pasture grounds, even if it is not superior to pasturing them in enclosures.

It is evident that the objections alleged against stall-feeding, and the consequent perfection of cultivation, are not tenable if separately considered; nevertheless, it cannot be denied that, when united together, they may, under certain circumstances, render the expediency of the adoption to be very doubtful, and even plead strongly in favor of pasturage when combined with a good rotation. In districts or countries where the details and arrangements connected with stall-feeding are yet unknown, or where the servants, or those charged with the duty of inspecting all the operations and proceedings, are prejudiced against it, this system will require more minute and careful attention than can be bestowed upon it by a person who is at the same time occupied in directing several other branches of rural economy. Previous to the introduction of stall-feeding, it will always be necessary, in order to secure success, to hire men, expressly for that purpose, who are capable of managing it properly.

This system requires a considerably larger *circulating capital*, not so much for itself as for the maintenance of the vigorous cultivation with which it is associated. It therefore appears to be peculiarly suited to those places and circumstances in which, so far from being obliged to derive a great portion of his income from the soil, the agriculturist possesses a surplus on which he can draw whenever occasion requires it; because, if the contrary was the case, he might not always find it easy, in a large undertaking, to raise the necessary funds for

defraying the cost of labor, and the other expenses attendant on this system.— Wherever the quantity of capital is circumscribed, alternate perfectionated cultivation with pasturage will be found much more advantageous, especially at the commencement, and afterwards it will be much easier to make the transition to stall-feeding. On the other hand, the advantages attendant on this mode of feeding cattle are increased in proportion to the value of the soil, and the tillage and ameliorations which are bestowed upon it.

There is no case in which so little profit is derived from this system as when it is practised on estates composed for the most part of sandy earth, which contains less than twenty-five parts in every hundred of argillaceous clay and mould. Soils of this nature are materially benefited by long periods of what is called "repose, or rest," by being left untilled, and by being pastured by cattle: they thus acquire some degree of consistency, which, however, they would soon entirely lose if they were too frequently plowed.

Land of this kind is also less suitable for cattle than for pasturing sheep, and for which animals stall-feeding has yet been introduced. Notwithstanding the abundant manuring which this system enables the farmer to bestow, there is always a great degree of uncertainty attending the cultivation of plants for summer fodder, on account of the occurrence of periods of drouth. However sure the farmer may feel of the success of the crops of roots destined for the winter fodder, he never can divest himself of a dread of the failure of the other crops.

A distinction has been made between complete and partial stall-feeding. The latter does not signify the practice which is sometimes met with, that of feeding one half of the animals in the stable while the others are turned out to pasture, but it is giving all the animals one portion of their food in the stable and the rest on pasture grounds.

Many persons have regarded this mode as by far the most profitable manner of feeding cattle, and the more so as the quantity of milk obtained from cows fed in this way is much greater than under any other circumstances. The change in the kind of food is certainly calculated to give the animals a better appetite, and also to stimulate their digestive organs to healthy action. This practice is peculiarly adapted to farms which are contiguous to lands which, either from the dread of inundations or from some other cause, can only be used as pastures, and which, nevertheless, are not sufficiently extensive or fertile to supply the cattle with all the food which they require for their maintenance during the summer.

Stall-feeding may be associated with various systems of cultivation, among which the three following are the principal modes:—

The first and most ancient method of procuring a supply of green provender for the cattle during the summer, consists in devoting certain enclosures or fields to the growth of clover. Pieces of land near to the farm buildings are usually chosen for this purpose; and these are sown every third year, and not unfrequently in the first year and with the first crop of corn with clover, which is to be cut while green; or, where the nature of the soil will admit, with lucerne. When this fodder is taken off the land, roots or cabbages are cultivated for one or two years, and sometimes a crop of corn or of some leguminous plant, and then the land is sown anew with fodder-plants. But these enclosures consume a very great quantity of the manure, and without frequent and repeated ameliorations, the clover crops, following so quickly on each other, cannot be made to succeed at all. The principal object of the cultivation of fodder, and of stall-feeding in general—that of procuring the greatest quantity of manure for the whole extent of the fields—is here entirely lost; and thus the otherwise absurd reproach so often made to the cultivation of green fodder, namely, that it requires more manure than can or ought to be bestowed on it, becomes, in some respects, true. Another consequence of this method is the annihilation of a second advantage attendant on the stall-feeding of cattle, and the consequent cultivation, viz: the alternate succession of green crops with crops of grain on the fields; a dead fallow must be introduced, or the land will speedily become infested with weeds. It is only when sown on open fields and introduced into the general rotation, that the green crops can fully attain the end for which they were destined, that they will effect a chemical amelioration in the soil by means of the manure which is applied to them, and a mechanical amelioration in it by means of the loosening and cleansing tendency.

The cultivation of plants for fodder on separate enclosures can therefore only be regarded as a very injudicious if not a pernicious means of procuring some additional provender for the cattle, on farms submitted to the systems of fallows, or of non-perfectionated alternate cultivation with pasturage; and it is utterly opposed to the end which stall-feeding, as it is generally conducted, has in view. An enclosure of inconsiderable extent situated near the farm buildings, and sown with perennial fodder plants, or with lucerne or grasses for mowing, may, nevertheless, occasionally be found useful, and may tend to facilitate the complete stall-feeding of cattle by furnishing a supply of provender at periods when it could not be obtained elsewhere.

The second method of obtaining fodder by cultivation consists in introducing the crops into the triennial rotation in the place of the fallow. We have already spoken of this method, which was principally propagated by Schubart, and have stated the advantages which may be expected from it, and the evils it possibly may produce. This mode does not deprive the soil of any portion of fertility; but, on the contrary, when the clover is vigorous, thick, and free from weeds, it communicates additional succulency and nutrition to the land. But the clover crop can only be expected to possess these three advantages under the triennial rotation, where it has been sown on peculiarly fertile ground, and where it is only sown once in nine years in the same place. The occasional failure and the frequent scantiness of the crops on estates which do not possess that additional extent of meadow land which is absolutely necessary to secure an adequate maintenance for the cattle throughout the summer and winter, has caused this method to be everywhere abandoned except in the most fertile districts; and the system of stall-feeding has, in consequence, fallen into disuse. Where the failure of the clover has been attributable to accidents, many industrious and persevering agriculturists have endeavored to remedy the evil by sowing vetches, or a mixture of various plants which may be mown while green, or by cutting down their peas to feed the cattle; but where this failure has repeatedly occurred, and has evidently been occasioned by some fault in the system itself; they have found themselves compelled to renounce it altogether; some few farmers have persisted in this mode of cultivation until their land became completely choked with weeds.

The third method, and the only one which has hitherto appeared to be really successful, on which stall-feeding can be based with any degree of certainty, is that of *alternate perfectionated cultivation*, in which clover is always sown on a soil that has been deeply plowed, and still retains all the fertility produced by the recent amelioration, and where it is possible to procure an auxiliary by the cultivation of other plants, as fodder for the middle of summer, autumn, and winter, so that the cattle may receive rich, abundant, and succulent food in every season of the year. We have already given a detailed account of the principles on which this system is founded; and as we shall have occasion to allude to it again when treating of the cultivation of plants and the feeding of cattle, we shall not enlarge farther upon it at present.

We shall here confine ourselves to an enumeration of those rotations which, taking into consideration the number of divisions of the land, produce the greatest quantity of fodder, and consequently, of manure, and with the sacrifice of the least possible portion of the crops destined for sale.

We will suppose that the soil consists of argillaceous earth, which contains at least thirty parts in a hundred of alumine and humus, and at most seventy parts of silex in a hundred; such a soil as in wheat land would be termed second-rate, in barley land first and second-rate, or among good soils would be classed as average or middling land. Clover certainly will also succeed on a lighter soil, which contains from twenty-five to thirty parts in a hundred of alumine, provided that the land has been properly manured; but the success is so very uncertain in dry years that no reliance can be placed upon it, where all the fields or even where only some of the divisions are composed of land of so light a nature; on estates of this kind, therefore, as we have already said, alternate perfectionated cultivation is always less casual. In making choice of the crops which are to form parts of these rotations, attention must always be paid to the more or less argillaceous nature of the soil, as well as to the calcareous matter and to the humus which has been more recently added to it. We shall give some directions with

regard to the manner in which these considerations ought to influence the choice of the rotation:—

Four Crop Divisions.

1.** Weeded crops, and in this number beans sown in rows may be included.
2. Barley.
3. Clover.
4. Rye or wheat.

From some incomprehensible misconception, this rotation, which is practised by a great number of English agriculturists, and which I used formerly to follow upon a small farm of my own, has been regarded by many persons as the only form of alternate cultivation. It is, however, suitable to estates of a very limited extent; on large properties it is found advantageous to increase the number of divisions.

Five Crop Divisions.

After the autumnal corn, a crop of oats may be obtained from the land without causing any bad effects, the succeeding weeded crop being intended to clear and clean the ground. In the experiments which I have made with regard to the rotation, I find that oats, when compared with other crops, are not sufficiently profitable to induce me to persevere in cultivating them. In those places where the great object in view is to secure as large a proportion of fodder for the cattle as possible, the clover may be suffered to remain upon the ground for two years.

Six Crop Divisions.

The first four follow in the same order as those mentioned above.

5.* Peas; which, if neccessary, may be succeeded by vetches to be mown while green.
6. Rye.

In these rotations I usually prefer autumnal corn to spring corn; the produce of the former being more to be depended upon, the crop yielding a much greater quantity of straw, and the operation of sowing—especially if carried into effect with the proper instruments—being much more easily accomplished after the fallow crops. Should any unforeseen occurrence prevent the whole of the land from being sown in the autumn, it is always possible to sow the remaining part with spring corn.

Seven Crop Divisions.

Here, also, a crop of oats may be obtained after the rye crop. In the greater number of cases, however, those persons who wish to preserve the fertility of their land, and also to establish the stall-feeding of their cattle upon a secure foundation, will do well to allow the clover to remain upon the ground for two years, and content themselves with two crops of autumnal grain, one of spring corn, and the half or two-thirds of a division sown with peas. Here, and in every case where a superabundance of root crops is found in the first division, beans, sown in rows and tilled with the hoe, may be substituted; and, after these have received the last tillage, radishes may be sown with advantage between the rows; and these latter may also be sown after vetches which have been mown while green; but they must be removed very early, in order to make way for the autumnal corn.

Eight Crop Divisions.

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Oats.
5.* Peas.
6. Rye.
7. Vetches.
8. Rye.

Or:

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Clover.
5. Rye.
6.* Peas and vetches.
7. Rye.
8. Oats.

Nine Crop Divisions.

1.** Weeded root crops.
2. Barley.
3 and 4. Clover.
5. Rye.
6.* Peas.
7. Barley.
8. Vetches.
9. Rye.

Ten Crop Divisions.

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Clover, broken up after the first cutting.
5.* Cabbages.
6. Wheat.
7. Peas.
8. Rye.
9.* Vetches to be mown while green.
10. Rye.

In order to cultivate cabbages, which crop is peculiarly adapted to this rotation, the farmer must have an abundance of manure at his disposal; but, with such a succession of crops, he will soon be possessed of that powerful auxiliary to his cultivation.

Eleven Crop Divisions.

The same as the foregoing, with the addition of a crop of oats after the rye.

Twelve Crop Divisions.

1.** Weeded root crops.
2. Barley.
3. Clover.
4. Clover.
5. Clover broken up after the first cutting.
6.* Cabbages.
7. Wheat.
8. Peas and vetches.
9. Rye.
10.* Beans sown in rows, and radishes.
11. Barley.
12. Rye.

Or, should it be deemed expedient to endeavor to obtain a still greater quantity of those products which find a ready and profitable sale, the farmer may, if he finds himself in possession of a sufficiency of manure, break up the clover on the fourth division immediately after the first cutting, and arrange the latter part of the rotation as follows:*

5.* Cabbages.
6. Wheat.
7. Vetches.
8. Rye.
9.** Tobacco.
10. Wheat.
11. Beans, succeeded by radishes.
12. Barley.

* The temperature of the north of Germany, for which these rotations are particularly adapted, is too unfavorable to lucerne to admit of the author's introducing that plant into his successions of crops; but such is not the case in France, for lucerne always thrives wonderfully well there; and when it is cultivated on land that has been properly manured, deeply and carefully plowed, and thoroughly cleaned from weeds, and which is not of too argillaceous a nature, nor too much disposed to become dry and hard, but has a tendency to retain water and moisture, this plant will prove the most advantageous of all those which are cultivated for the purpose of feeding cattle. Without any wish to anticipate those details which properly belong to that portion of the work which treats of the cultivation of vegetables, I must, nevertheless, here observe that lucerne will yield plentiful crops for four, six, eight, and sometimes ten years, according to the care bestowed upon the sowing and the treatment of it; but the finest and most abundant crop is produced in the third year: from that time it becomes more or less mixed with weeds, which, in the end, entirely choke it. In places where there is a great extent of meadow land, and, consequently, where the wind scatters the seed of gramineous plants in all directions, the lucerne becomes deteriorated much sooner than in those situations where the greater part of the land by which it is surrounded is submitted to the action of the plow and to a good rotation. But it sometimes happens that the plants which thus become mingled with the lucerne are so well adapted for fodder, and yield such a plentiful and useful produce, that it still continues to be advantageous to suffer the lucerne to remain on the ground.

The propriety and utility of cultivating old lucerne ground will depend, in a great measure, upon local considerations, and upon the relative advantages which the soil might be made to produce in each of these occupations; but if the lucerne has been suffered to remain upon the ground until the plants perish of their own accord, it becomes absolutely indispensable that the soil should be thoroughly and abundantly manured, carefully cleared of weeds, and also allowed a very considerable interval of repose; without the fulfilment of these conditions, there will be every reason to fear that the lucerne will not succeed when sown afresh.

In districts where the soil is easily tilled, and where laborers are not scarce or wages expensive, it appears to be advantageous to allow the lucerne to remain on the ground for five years only, and then to plow it up and sow autumnal corn, for which, under these circumstances, this plant forms an excellent preparation.—After one, or even two, consecutive crops of winter cereal plants, which will succeed very well without manuring, and in which it is only necessary to keep the soil free from weeds, a cleaned crop may be made to supervene, such as potatoes or beet-root, which seem to me in this place to succeed better than carrots or ruta-bagas.

I will here give, as an example of this kind of cultivation, the excellent rotation which M. Charles Pictet has used for some years past. This gentleman is a zealous agriculturist, and one who devotes his whole attention to the study of that science, and to the propagation of new and enlightened views of every portion of it. I extract this rotation from No. 12 of the "Bibliothica Britannica," Dec. 1810, in which work the author describes it in a manner which is at once lucid, instructive and interesting. I must also add that I have had frequent opportunities of observing the admirable manner in which it acts on an estate cultivated by M. Pictet, at Lancy:

1. Potatoes, preceded by the ground having been deeply dug up with a spade.
2. Wheat, thoroughly manured with dung spread over the seed in the winter, which improves the surface of the soil, and ensures the success of the clover, which is sown on it in the spring, and then covered by a long-tined harrow.
3. Two cuttings of clover.
4. Wheat, and sometimes roots as a second crop.
5. Potatoes, as in the first year.

The Transition from one Rotation to another.

No prudent agriculturist will exchange his present system of cultivation for another, even a better one, without maturely weighing and considering all the circumstances of his situation. We are now about to lay down a few general rules on this head, which will be found applicable to almost every situation and locality.

In the first place, the transition to a more perfect rotation cannot be effected without the outlay of a considerable capital. There certainly are cases in which this end may be attained by the outlay of a large or a small sum, but much sooner and more effectually with the former than with the latter, supposing that the director of each undertaking possesses an equal degree of skill. In order to augment the quantity of fodder which is the groundwork of all ameliorations a temporary sacrifice of some portion of the saleable products must be made; and this can only be done by diminishing the extent of ground sown, and which diminution cannot be compensated by any augmentation of the produce of the remainder; or else by diminishing the allowance of manure, and employing a portion of it in the cultivation of plants for the purpose of feeding cattle. To this must be added the expenses attendant on the necessary increase of live stock, servants, and laborers. It is quite a mistaken notion, however, to reckon these outlays as so many sacrifices: they are neither more nor less than sums advanced for the purpose of communicating fresh vigor and greater activity to all the operations; and, unless some extraordinary ill-fortune attends the agriculturist, the capital thus expended will, in a short time, be repaid with interest. Nevertheless, it is perfectly useless for any one who cannot command the necessary funds to attempt this transition, at least with any chance of success.

The requisite amount of capital, as we have already said, varies in different cases. If the agriculturist wishes to proceed with tolerable rapidity, and, at the same time, with all requisite circumspection, he must possess a capital at least double in amount of the net produce which the estate formerly yielded. He must not be in too great haste to increase the number of his live stock; neither must he make any changes, alterations, or additions to his farm buildings, which are not absolutely and palpably necessary.

It is impossible to effect any profitable modification in the cultivation of an estate without the outlay of a certain capital; wherever such a thing appears to have been done, it has either been effected by a continued system of economy carried through every branch of the farm management, or by means of the application of additional labor. The want of capital, or at least of the will to employ it in furtherance of this end, is the great cause of most of the failures in enterprises of this nature. It is of the greatest importance that all persons should be impressed with a conviction of this truth, and that those prejudices which still exist against it should be wholly removed.

Another absolutely essential preliminary is that the farmer shall be sole and absolute master of all his land, free to act, and unfettered by any trammels and servitudes; and whenever the contrary is the case, his first step must be to obtain an exemption from all restrictions which might confine his freedom of action.

The process of effecting a transition from a triennial rotation with fallowing to an alternate rotation associated with stall-feeding, on an estate already di-

6. Wheat as in the second year, but with this difference, that lucerne is sown instead of clover in the spring.
7 and 8. Lucerne.
9. Lucerne, thoroughly manured during the winter.
10. Lucerne, broken up in the summer.
11. Wheat.
12. Wheat, succeeded by radishes.

This rotation is far from being an expensive one to M. Pictet, and for the following reason. The greater part of the potatoes are cultivated by the poor people in the neighborhood, who, in return, receive one-half of the produce, which serves to prevent them from suffering from want. Thus M. Pictet is the benefactor of a great number of poor families, at the same time that he derives his own share of benefit. I would advise all my readers to peruse the account which this gentleman himself gives of his rotation, and only regret that I cannot transcribe the whole of it here. Sainfoin ought not to be forgotten: this plant is calculated as well as lucerne for alternate rotations. The produce, certainly, is not so abundant as the other; but it does not require so much manure, and will flourish on sandy and gravelly soils, where lucerne can never be made to vegetate with any degree of success. Besides the seed of sainfoin being much more expensive than that of lucerne, it is scarcely worth while to sow fields with this plant merely for a limited number of years. [French Trans.

vided, is not attended with difficulty if each of the fields have been regularly ameliorated. But in those places where it has only been possible to manure thoroughly a portion of the arable land, and where the remainder has been but slightly or not at all améliorated, much greater obstacles are met with, nor can it be expected that this object can be effected without the aid of extraneous means. As it is not, however, absolutely indispensable in this case that the divisions should be contiguous and that the numbers should follow each other in regular succession, as in all rotations that are associated with pasturage, every thing will be gradually got into the proper order. If, as is generally the case, the lands which were not comprehended in the rotation lie at some distance and contiguous to each other, it will generally be more advantageous to adopt two or more courses of cropping, or to divide the arable land into exterior and interior divisions, and in the first place to ameliorate the latter and then wait until the fertility of these fields and the abundance of manure produced by them, shall make it easy to bestow some amelioration on the former. If this mode cannot be adopted, the manuring of the principal divisions will be delayed, and it will be necessary to abstain for a longer period from the cultivation of vegetables for sale.

Should the position and form of the fields appear to render it necessary, matters may be so arranged that each fertile division shall have a supplementary portion of poor and ill-conditioned land, even though if should not be contiguous. This additional part must be gradually amended and improved, in the course of cultivation, until it becomes equally good with any of the other portions. In order to effect this result, it must be allowed a longer period of repose, and only occasionally made to produce a crop of the same kind as that borne by the principal division.

In effecting this transition from a rotation with fallows to the alternate system, the principal object to be kept in view is the speedy augmentation of the quantity of fodder in order to obtain a larger supply of manure. This can only be done by diminishing the grain crops: but the retrenchment must not be made on the autumnal corn, or in the manure which ought to be devoted to them; because that crop not only yields a larger produce in grain, but also furnishes a greater quantity of straw.

Section III.

AGRONOMY;

OR, A TREATISE ON THE CONSTITUENT PARTS AND PHYSICAL PROPERTIES OF THE SOIL, AND THE BEST METHOD OF ACQUIRING A KNOWLEDGE OF THE DIFFERENT EARTHS, AND ASCERTAINING THEIR VALUE.

"What may not enlightened citizens accomplish, who have discarded the false and bustling pleasures of towns, and, carrying into the country the knowledge they may have acquired, apply to Agriculture the rich and varied assistance of the physical sciences!" [*Fourcroy.*

The soil bears the same relation to agricultural industry as primitive substances do to manufactures in general. The agriculturist endeavors to find land that shall unite all the qualities he requires, with the same anxiety and care that a manufacturer bestows on the selection of the materials best adapted for his purpose. Each of these persons exercises all possible judgment in forming a just estimate of the value of the article which he is about to purchase or obtain possession of, in order to avoid giving more value for it than it is worth. Each of them, also, when he has obtained the substance or matter which he requires to

work with, examines its merits or demerits more narrowly, gives to each of its parts that destination for which it appears to be best adapted, and by means of which he may derive the greatest possible amount of profit both from the substance itself and from the labor which is applied to it.

The manufacturer loses both time and money when he attempts to fabricate fine cloth from coarse or jagged wool, and lessens the value of the materials when he endeavors to make coarse cloths from superfine wool. He must, therefore, divide and arrange all his wools according to their various degrees of fineness; and in order to be able to do so properly, he will require much more experience and a far greater knowledge of the subject than is necessary to assist him in the comparatively simple act of making his purchases. In the same way, the agriculturist must not content himself with understanding the directions given in a previous section of this work for the choice and purchase of an estate, if he would derive the most satisfactory amount of profit, both from the soil which he has to work on and from the labor that he applies to it; if such be his aim, it can only be effected by means of a judicious selection of products, based upon a thorough knowledge and just appreciation of the nature and properties of the soil in which they are to be sown.

The seeds, roots, and germs furnished by nature are to the agriculturist what the designs and models fashioned by art are to the manufacturer. The principal aim and study of the farmer ought to be to allot to each of these seeds the soil which is most proper for it, and to bestow on that soil the species of cultivation best adapted to its nature; and the more thoroughly he has made himself acquainted with the properties of the land he has to work on, the better will he be able to fulfil his task.

But a just appreciation of the nature and properties of the soil can only be founded upon sound notions of chemistry and of physics. Although practical knowledge acquired from long experience may be sufficient to enable persons to recognize and appreciate certain particular kinds of land, yet it can never be applied generally to all varieties; experience with respect to one kind would only lead to error, if the results deduced from it were applied indiscriminately to all others, many of which are of a totally different nature, although perhaps apparently the same to one whose knowledge is merely superficial, and not based on science and on a careful study of the subject.

We shall now, therefore, enter into a minute examination of the different kinds of land, taking for our guidance those discoveries in natural philosophy which have latterly thrown so much light upon this subject. So short a period has elapsed since the united attention of agriculturists and naturalists has been seriously directed to this point, that there, doubtless, still remains a wide field for useful investigation, and a vast number of points which require to be better understood; but the knowledge which we have already obtained is sufficient to enable us to form more just ideas on many subjects, and to avoid former errors; and, with study and perseverance, there is little doubt that we shall speedily arrive at that precision and exactness which is so desirable to be attained. In order that we may be able to profit by the experience and discoveries of learned men, it is highly necessary that we should enter the domains of natural history, and endeavor to acquire clear and distinct notions of all the constituent parts of the soil, and of their properties; and as these considerations will lead us to the theory of manures, or of the chemical amelioration of the soil, they will prepare us to enter on that subject when it comes before us.

The surface of our planet, being composed of that loose friable matter which we call the *soil*, or, in other words, the *earth*, is an assemblage and combination of a variety of heterogeneous substances. In common language, we call this mixture "earth;" but it comprises matters which would not be classed under that denomination by any chemist or natural philosopher, though the greater part of it does consist of earths properly so called. The constituent parts of this mixture are the earths *silica*, *alumina*, *lime*, and sometimes *magnesia*; portions of *iron* and other elementary substances are also found in it, but these latter are always in smaller proportions than the earths. Besides these simple substances, fertile land contains an exceedingly compound matter, which, on account of the pulverulent form, has been called *mould*, *vegetable mould*, *vegeto-animal earth*, &c.; and which differs so materially from earths properly so called, that it ought

never to be confounded with them. In order to distinguish it from the primitive earths, we have thought proper to designate it by the Latin word "*humus,*" which we shall henceforth use exclusively in this sense.

The following is one of the principal distinctions between *earths* and *humus.* That, as yet, no agent has been discovered by means of which the former can be decomposed; they appear to be immutable, and cannot be destroyed or essentially changed by any known power in organized nature. The *humus*, on the contrary, is very susceptible of decomposition; it is a matter produced solely by animal and vegetable life, and can be changed and destroyed in itself and by itself, and particularly by the action of exterior bodies. It is reproduced upon the surface of our soil by organic action, and consequently at different periods; and is found even in the same place to vary in quantity as well as in quality.

We will commence by considering those immutable earths which form the basis of the soil, and which are on this account termed "elementary earths;" we will, in the first place, consider them generally, then subsequently in their pure state, and lastly under all those combinations and mixtures in which they most frequently occur. From the position in which these earths are found, being mingled together on the surface of our globe, it appears probable that they did not originally exist in the pulverized state in which we now find them, but rather that the surface once consisted of a solid mass of enormous mountains and valleys, somewhat similar to those which, by the aid of good astronomical instruments, we can trace on the surface of the moon. This solid mass has been gradually loosened and worn away by the action of fire, air, and water. It is well known that lands situated above the level of the sea attract, in proportion to their magnitude, a larger portion of that aqueous vapor which the heated atmosphere continually absorbs from the surface of seas and lakes; by this means the higher regions become permanent reservoirs of water, which occasionally breaks the limits, rushes down the declivities with great velocity, irrigating the valleys and plains below, and carrying with it fragments of earth, rock, and stones of all sizes, which are deposited at the bottom, and successive layers of earth are thus formed. There cannot indeed be a shadow of doubt that the strata of earth which we meet with, especially in countries bordering upon mountains, have been produced and transported there by inundations and torrents, and by the constant action of water; we do not mean to assert that they have been formed at once, but that they have been the work of time, and of the depositions of repeated inundations. One fact which appears to confirm this supposition is, the circumstance of these strata being seldom or never deposited according to their specific gravity, but usually alternating in a totally opposite manner.

The motive which principally induces us to dwell on this subject is our sense of the vast importance which a knowledge of it may be to an agriculturist, as enabling him to discover springs and subterraneous water-courses, to conduct the operations of draining, mining, and digging, in search of valuable earths or stones, as marl, lime, coals, &c., of all which substances we shall presently have occasion to speak.

On plains and flat surfaces the layers of earth are generally found to be deposited in a horizontal or slightly inclined position, very similar those strata which we see formed by the depositions of water. Sometimes these layers extend, in one uniform thickness and similar composition, for an immense distance, so that they appear to have been gradually deposited over the whole surface one after another by repeated general inundations. At other times they form a kind of bank, thrown up, as it were, at different periods by currents of water, or are forced into the clefts or sinuosities of the rocks in jets or veins; they are also frequently found heaped irregularly together, forming a promiscuous mass of earth and stones, which has every appearance of having been torn up and thrown together by some convulsion of Nature.*

* "Rocks," said Davy, "are generally divided by geologists into two grand divisions, distinguished by the names of primary and secondary. The primary rocks are composed of pure crystaline matter, and contain no fragments of other rocks. The secondary rocks, or strata, consist only partly of crystaline matter, contain fragments of other rocks or strata, often abound in the remains of vegetables and marine animals, and sometimes contain the remains of land animals. The number of primary rocks which are commonly observed in nature are eight:—1. *Granite*, composed of quartz, felspar, and mica; when these are arranged in regular layers in the rock it is called *Gneiss*. 2. *Micaceous schist*, composed of quartz and mica. 3. *Sienite*, which consists of hornblende and felspar. 4. *Serpentine*, composed of felspar and resplendent hornblende. 5. *Porphyry*, which consists of felspar. 6. *Granular* marble, or pure carbonate of lime. 7. *Chlorite schist*,

In the neighborhood of mountains of the second order, and indeed in all mountainous countries, numerous irregularities are perceptible. The layers of earth and stone are sometimes found in a horizontal position, but as they approach the hights they assume a different direction, being now oblique, now parallel with the surface; and sometimes the oblique layers are intersected by vertical ones. Even in this formation, however, a certain degree of order is observable; the perpendicular and oblique layers appear to have been thrown up by some subterraneous power or volcanic action, and torn from the beds on which they formerly reposed.

Beds of various kinds are met with on the very summits of mountains, which, if sought for on the plains, would be found situated at a considerable depth below the surface. If some particular kind of stone or earth is found at the outlet of an opening, or on the summit of a mountain, we may expect to find the same kind occupying a like situation among the layers on the plains, if we dig deep enough to reach it. But, as the profundity at which these beds must be sought for in the plains is in proportion to the elevation of the mountain, it often becomes impossible to reach them at all. It not unfrequently happens that it is necessary to seek for coal, lime, or marl, on the mountains and elevations, although there is not a doubt that the plains contain an equal quantity of these substances. Even on the mountains, these layers of earth usually show themselves on that side towards which they incline, and whence the greater quantity of water oozes, because this fluid carries away with it the superior layers of loose soil.

I imagine that most of my readers are conversant with the elements of Chemistry; but we must, nevertheless, enter with some degree of precision into that portion of the science which treats of earths, and which is calculated to enable us to form a just appreciation of the nature and properties of the soil with reference to Agriculture in general. In fact, although many writers have latterly discussed this subject in a manner likely to prove conducive to the end in view, yet many portions of it still remain for deeper research, and require to be treated in a manner better adapted to benefit agricultural pursuits than they have yet been; especially as the unexplored portions, left in different places, appear to have given rise to numerous and very serious errors and misunderstandings. A knowledge of this department of Science is indispensable to an enlightened agriculturist, for such a knowledge can alone point out to him the causes of the different phenomena which occur in the course of his operations, and afford him a satisfactory explanation of various results which must otherwise appear contradictory. A perfect acquaintance with the earths and their properties also teaches the agriculturist how to derive the greatest possible advantage from those powers which Nature has placed at his disposal in the land which he possesses, and where it will be profitable to establish lime-kilns, glass-houses, manufactories of tiles, potteries, &c. Lastly, it is this knowledge only which can afford a sure guidance, if he would profit by the extensive means of improving and enriching his land, afforded him by the power of extracting various kinds of earths from the substrata of the earth, and spreading them over the surface. It is for these reasons that I have considered it absolutely necessary to introduce this portion of Chemistry here.

Until the middle of the last century, chemists admitted the existence of only one elementary earth which they supposed to be the principal constituent portion of our globe, indestructible in the highest degree, and entering more or less into the composition of all solid bodies. It was not until that time that the difference

a green or grey substance somewhat analogous to mica and felspar. 8. *Quartoze rock*, composed of quartz. The secondary rocks are more numerous than the primary; but twelve varieties include all that are usually found in these islands:—1. *Grauwacke*, which consists of fragments of quartz or chlorite schist, imbedded in a cement principally composed of felspar. 2. *Silicious sandstone*, which is composed of fine quartz, or sand united by a silicious cement. 3. *Limestone*, or carbonate of lime, more compact in its texture than in the granular marble, and often abounding in marine exuvia. 4. *Aluminous schist*, or *shale*, consisting of the decomposed materials of different rocks, cemented by a small quantity of ferruginous or silicious matter, and often containing the impressions of vegetables. 5. *Calcareous sandstone*, which is calcareous sand cemented by calcareous matter. 6. *Ironstone*, formed of nearly the same materials as aluminous schist or schale, but containing a much larger quantity of oxide of iron. 7. *Basalt* or *whinstone*, which consists of felspar and hornblende. 8. *Bituminous* or common coal. 9. *Gypsum*, or sulphate of lime. 10. *Rocksalt*. 11. *Chalk*, which usually abounds in remains of marine animals, and contains horizontal layers of flints. 12. *Plum-pudding stone*, consisting of pebbles cemented by ferruginous or silicious cement."

[*Elem. Agri. Chem. p.* 192.

between *alumina* and *silica* began to be perceived. *Lime* was not included among the number of earths, but regarded as a compound body. But, as chemists extended their researches farther into the mineral kingdom, they began to appreciate the principal characteristics which serve to distinguish not only the elementary earths already known, but also several new substances which were included in the class of bodies which do not admit of decomposition.

The previously received opinion, that earth was a tasteless and insipid body, and insoluble in water, was abandoned: the theory of one single elementary earth was exploded, and each separate kind regarded as a distinct element.

The word "earth," as denoting a body, or any determinate kind of matter, ought, perhaps, to be altogether banished from the science, or applied to those only which are insipid and insoluble in water; it is not possible to give any satisfactory definition of that substance which chemists call "earth."

Silica and *alumina* are the most abundant of all the earths, and, I may also add, whose properties are the best defined. Next to them *lime* is most abundant, and exhibits the most marked characteristics; but it resembles the alkalies more than either of the former, which possess no alkaline nature. *Magnesia*, which was so long confounded with the other earths, has at length been recognized as a distinct substance. It now forms a connecting link between the insoluble earths and the alkalies, and the connection thus formed may, for the present, justify the association of all the natural crude earths in one class. The decomposition of certain mineral products and stony bodies has successively brought to light a number of new simple substances which may all be ranged in the class of earths: some of these are nearly allied to *silica* and *alumina*, and others to the alkalies. A few years ago there was a rage for the discovery of elementary bodies, and, consequently, many chemical products which have since been discovered to be compounds were then set down as simple elements. Most chemists of the present day reckon nine sorts of elementary earths, and of this number five are wholly uninteresting to us, because they are seldom or never found in the form of earths on the surface of our soil.

Since, notwithstanding all the endeavors which have been made, no one has yet succeeded in decomposing the pure earths before mentioned, they must be considered as *simple* or *elementary* bodies. Nevertheless, various phenomena which have been minutely observed render it no longer doubtful that these are compound substances, since they are formed in organized bodies. Schrader, of Berlin, has proved that gramineous cereales which have been carefully prevented from coming in contact with lime, contained more lime and silica than the seed from which they grew. De Saussure has also found a quantity of lime in the ashes of various kinds of wood which had grown upon a soil absolutely free from that substance, and the same observation has been also made of Einhoff. Vauquelin has shown that the excrements and eggs of chickens contain a much greater quantity of lime than the food given to these birds. Now since, according to the atomic theory, all effects in nature consist in the motion and reciprocal action of substances already existing, it is evident that no body can be produced by natural processes, unless the elements are already in existence. A substance cannot, therefore, be regarded as simple when the time of the formation can be fixed; it must, on the contrary, be regarded as a compound.*

The earths are indestructible by fire, and they may be exposed to the most violent heat without volatilizing; they are all infusible when exposed separately to the action of heat; neither can they be fused in a fire fed with oxygen gas: but it is a very remarkable fact that they lose this character when several of them are mixed together. Silica, lime and alumina are infusible when exposed separately to any degree of heat, but are easily melted when put together in a mass. According to the greater number of experiments, the earths have no affinity for

* The discoveries of Davy and others have shown that the earths, such as lime and magnesia, are really compound bodies, composed of metals and oxygen. The correctness of the experiments to which M. Thaer alludes, with regard to the supposed power of certain plants and animals *to form* the earths from other substances, we cannot but regard as exceedingly doubtful.

These earths have been found by modern chemists to be compounds of peculiar metals with oxygen gas, or vital air, in the following proportions:

Lime	is composed of	calcium,	71·42	parts;	oxygen,	71·42 parts.
Alumina	"	aluminum,	56·895	"	"	43·105 "
Silica	"	silicon,	49·888	"	"	50·112 "
Magnesia	"	magnesium,	40·	"	"	60· "

oxygen, and, for this reason, they are incombustible. Nevertheless, Humboldt has thought that several of them, and particularly alumina, have some affinity for oxygen, even when in a state of perfect purity. Others, again, have denied the truth of this assertion, believing that the affinity in question has no existence unless the earth contains a metallic oxide or some combustible matter. This question, however, is not so important with regard to the art of fertilizing the soil as many persons may imagine, because there is no soil wholly free from metallic oxides and combustible matter.

The color of all the earths is a pure white; the hue which they exhibit in their natural state arises from the admixture of other substances, and chiefly of oxide of iron in various modifications; if that substance did not exist, the surface of our globe would appear perfectly white.

The earths differ from one another in their relations to water. It has already been observed that lime and some other earths are slightly soluble in water; lime requires 680 times its weight of water to dissolve it completely. Alumina and silica are absolutely insoluble; and as to magnesia, water dissolves an extremely small portion of it, not more than the ten-thousandth part. All earths, however, contract a mechanical union with water, and retain a greater or less portion of it after admixture. We shall designate this property by the term "cohesive attraction;" it not only varies in the different earths, but also in the mixtures formed with them: so that, according to general experience, the quantity of water which these bodies retain when mixed is not equal to the total amount which would have been retained by them all, if the quantity of it present in the mixture had remained separate. Thus, alumina and silica retain a much greater quantity of water when mixed together than they would have absorbed in a separate state. It is very important to determine the degree of cohesive attraction existing between water and the various kinds of earthy mixtures. In order to accomplish this, a portion of the earth to be examined must be dried, until its weight is no farther decreased, even by exposure to a temperature equal to that of boiling water. A weighed quantity of it should then be carefully mixed with water, and the mixture poured upon a horse-hair sieve, the weight of which has been previously ascertained; the superabundant water must then be allowed to drop or drain out, and, when the water is no longer emitted, the earth should be weighed again, together with the sieve: the weight of the sieve, and that of the earth before it was mixed with water, must then be deducted from the amount of the present weight, and the result will show the quantity of fluid which the earth has absorbed.

As there are many soils which absorb water in larger quantities without permitting it to drain away, and, nevertheless, allow it to evaporate with greater or less facility when they are heated, it is likewise necessary to pay attention to this tendency. In order to determine the degree of cohesive attraction of earth for water in this respect, various kinds of earth must be exposed to the same degree of heat, and observations made of the time which each of them takes in becoming perfectly dry.

The earths, and especially alumina, never entirely part with water, but retain a portion of it even when they appear to be perfectly dry; nor can they ever be altogether deprived of it, except by exposure to a very high degree of heat, such as that of incandescence or becoming white. In this operation, also, it is necessary to take for a standard a certain degree of temperature at which the drying is carried on.

It is true that the earths cannot be made to combine with pure nitrogen, carbon, or hydrogen; there are, however, several reasons for believing that they enter into combination with these substances when the latter have previously been united among themselves, and that they absorb and incorporate jointly the organic matter produced by this combination, such as the gases and other results of putrefaction. Various phenomena of vegetation appear to demonstrate this supposition. We shall have occasion, hereafter, to revert to this subject.

The alkaline earths combine with sulphur, both when these substances are fused together and when they are boiled in water; these combinations are, in general, very similar to those formed by the union of sulphur with the alkalies. They formerly received the name of "livers," because they bear a certain resemblance to that viscus, (they are the sulphurets of modern chemists.) It is proba-

ble that these earths form similar combinations with carbon strongly hydrogenated, and particularly with that which contains a small portion of azote—that is to say, with the result of putrefaction; but that these combinations are speedily decomposed at a higher temperature.

All the simple earths, except silica, have a great affinity for acids, and are soluble in them. The acid becomes saturated and neutralized—that is to say, it loses its acid properties; but a similar effect is produced upon the alkaline earths, as they lose their peculiar action upon plants and organic matter when combined with acids. The products of these combinations are earthy neutral salts, either more or less soluble, or perfectly insoluble in water. It is chiefly from their action when brought into contact with acids, viz. the formation of earthy salts and the neutralization of the acids, that the earths are distinguished from each other.

But the elementary earths have also an electric affinity or chemical attraction for each other. Many earthy matters and minerals which we meet with in Nature are not merely mixtures, but absolute combinations of earths, in the formation of which the metallic oxides seem to be concerned. Earths may be made to combine chemically by being melted together; but it also appears that this union may be brought about in other ways. According to the experiments of Guyton and Godelin, some earths—as, for example, lime and silica, and alumina and silica—precipitate one another from their solutions, not by the one combining with the acid or alkali in which the other is dissolved, and so separating them, but by entering into combination with the other earth itself. This intimate union of the earths will be of very great scientific importance when the phenomena of the soil shall have been more examined and is better understood.

We shall now proceed to treat of those simple insoluble substances called "silica" and "alumina," in their state of chemical purity, and point out their leading properties, and then go on to examine all the various combinations in which they present themselves to us in nature. Having discussed these matters, and having entered into a more complete examination of the vegetable soil, we shall consider the alkaline earths in their pure state, and, subsequently, the compounds which result from the union of other earths with them. All these subjects will be considered with reference to the use which may be made of them in explaining and teaching the theory of the soil, of manures, and of vegetation; which theory ought to be altogether based upon the physico-chemical doctrine in question.

SILICA.

This earth derives its name from "*silex*," which, as well as "*quartz*," is almost entirely composed of it; and, in consequence, it was formerly called "*quartz-earth*;" and from the circumstance of forming glass when combined with alkalies, "*vitreous-earth*;" and lastly, since in the opinion of ancient chemists it was the primitive earth, and as it actually does exhibit in an eminent degree all the properties attributed to earths in general, it was called, "*elementary earth*."

Silica occurs in nature more frequently and abundantly than any of the other earths. All hard stones which give out sparks when struck by steel: the enormous mountain masses of granite, porphyry, gneiss, &c., together with the vast oceans of sand in deserts and in plains, are mainly composed of silica.

Generally speaking, there are very few, if any, stones in nature which do not contain more or less of this substance, and there is scarcely a single plant that does not contain and yield it after combustion in the form of ashes. Grasses, in particular, contain large quantities of it; and it is sometimes found crystallized in the epidermis. But, like the other earths, it is rarely found in a state of absolute purity; and quartz itself, of which it forms the greatest part, also contains an admixture of alumina and oxide of iron.

It is only, in fact, by means of artificial processes that silica can be exhibited pure and free from all other mineral substances. It then appears in the form of a very fine white impalpable powder, adhering a little to the fingers, and exhibiting a kind of roughness when pressed or rubbed. It is totally devoid of taste and smell. It undergoes no change when exposed to the action of fire, and neither fuses nor volatilizes, whatever degree of heat may be applied.

Silica has no affinity for water; indeed, without the aid of an intermediate substance, it is impossible to dissolve the smallest portion of it in that fluid.

When mixed with water it speedily falls to the bottom, without leaving behind the least portion in solution. There are, nevertheless, certain natural springs which contain silica in solution, but in which the minutest researches of *Bergmann* and *Klaproth* failed to discover the slightest trace of any substance capable of facilitating this conbination; and we cannot, therefore, explain the manner by which Nature has brought it about. The most remarkable of these phenomena is that of Geiser, in Iceland; a very hot spring which deposits a border of silica around its basin, and forms crystals, stalactites, and incrustations.

The mechanical cohesion between silica and water is also very trifling. When silica is moistened, it does not imbibe the water with avidity; neither does it form a tenacious, ductile, and unctuous paste with that fluid: at the utmost it never retains more than half its weight of water, and it also allows that fluid to evaporate very quickly.

The following is one of the characteristics by which silica is chiefly distinguished from most other bodies; that it is not operated upon or dissolved by any acid, excepting the fluoric. Silica reduced to a fine powder may be boiled with sulphuric, nitric, or muriatic acid, without the smallest portion of it being taken up. It is only when in a state of fusion that borax and phosphoric acid combine with it. Fluoric acid is the only one that dissolves it, forming with it a gaseous compound, and thus possessing the power of carrying the fixed substance with it when evaporated.

The fixed alkalies, on the contrary, whether in their caustic state or combined with carbonic acid, easily unite with silica, and quickly dissolve it. If potassa or soda be fused in contact with silica, it will cause the silica to fuse and enter into combination with it. The product resulting from this combination varies in its nature according to the proportions of the component substances employed, when silica is the predominating ingredient, the resulting compound is the useful substance of glass. The greater the quantity of silica, the more capable is the glass of resisting the action of air and acids. If, on the contrary, too great a quantity of alkali has been used, the glass soon becomes dulled by exposure to the atmosphere, and is likewise much more susceptible of the action of concentrated acids. During the fusion, metallic oxides are absorbed by the glass, to which they impart various colors. The green hue so frequently seen is produced by oxide of iron being combined with the silica. When this glass is subsequently de-oxidized by the act of the solar rays, it loses the transparency, and becomes tinted with the various hues of the rainbow.

When the alkali predominates, and the mixture is composed of four parts of alkali and one of silica, the product is a vitreous transparent mass, which quickly absorbs moisture from the air, and resolves into a thick liquid. This substance is perfectly soluble in water, and is known by the name of *silicious liquor*, or solution of flints.

We thus obtain a solution of silica, but only through the medium of its combination with an alkali. If the alkali be neutralized by an acid, the silica will be precipitated from the solution, and fall to the bottom of the vessel. It is only when the silicious solution contains too great a proporion of water, or when an excess of acid has been added to it, that the precipitation does not take place until the liquid has been evaporated. This phenomenon has received several very different explanations; the probable cause is the excessive weakening of the attraction of cohesion between the particles of the silica. A more systematic and certain method of obtaining pure silica is, therefore, to evaporate the silicious solution diluted and saturated with an excess of acid, then again to dilute the residue with water, and wash the precipitate several times.

Among the bodies in whose composition silica forms the principal ingredient, and which exhibit its characters in the highest degree, we shall notice the following, as those of which it may be useful to the agriculturist to possess some knowledge.

1. All precious stones, with the exception of the diamond: viz., the *ruby*, *sapphire*, *emerald*, *chrysolite*, *topaz*, *hyacinth*, *amethyst*, *chalcedony*, *cornelian*, *agate*, and *garnet*.

2. *Fire-flints* and *petro-silex*. The first of these are found in heaps on all plains, especially in countries which have a sandy soil, and also in chalk hills, embedded in the purest chalk. Geologists have long been endeavoring to dis-

cover how the flints came to be lodged or produced in such a situation. There is some plausibility in the supposition that the lime has been converted into silica, for the transition of lime into a state of flint is often observed; and organic remains are frequently found in the middle of the flint, thus proving its recent formation. The utility of this kind of flint is as notorious as it is extensive. The fabrication into gun-flints is of great importance. Formerly, this art was only known and practiced in England, Spain and France; it is now understood and used in the Austrian States. We may also observe that the ideas formerly entertained with relation to this kind of manufacture were rather singular; it was thought that the stones were found in a rough state upon the mountains, and cut and sharpened by machinery. At present, there is no doubt that they are manufactured by steel tools worked by the hands of skillful workmen. All fire-flints, however, are not equally well adapted for this purpose: some are too soft; while others, when struck by the hammer, fall into irregular fragments. Frederic William the First, king of Prussia, sent an armorer to St. Ange, to work there, and learn the art of making gun-flints. This man learned the art, and returning after a time, made flints with the stone found in Prussia; but they were so brittle that they flew to pieces on the second firing.

Besides this use of them, fire-filints are also employed in the manufacture of enamel, and of stone-wares; likewise for polishing glass, making burnishers for book-binders and gilders, and in the composition of glass, especially of that beautiful substance called English flint-glass.

Petro-silex, or the *horn-stone* of the Germans, bears some resemblance to the preceding, but it has the dull appearance of horn and a scaly fracture.

3. *Felspar* has a lamellated texture, and is frequently flesh-colored; it breaks into rhomboidal fragments. It is found, in beds and veins, in several other kinds of stones.*

4. *Quartz* is composed of crystalline and vitreous particles. It breaks into angular fragments. It is often found of a white hue and transparent, sometimes in large masses and sometimes in crystals. When these latter are large, transparent, and of a columnar shape, it is called *rock-crystal*.

5. *Granite, gneiss* and *porphyry* are composite minerals, possessed of great hardness, and are formed of different stones. They constitute the basis of primitive rocks, and are also met with in large masses in plains. Granite is composed of quartz, felspar, and another stone of an argillaceous nature, called "*mica*."† The grain, as well as color, varies in different ways. Gneiss closely resembles granite; it is composed of felspar, quartz, and mica; the parts are more intimately united than those of granite, and it generally presents a schistose and lamellated texture. Porphyry consists of felspar, quartz, and hardened clay or jasper, and sometimes also of a portion of mica.

6. *Sand* is probably formed, for the most part, of quartz, as it does not differ essentially from that mineral in its chemical composition. Immense floods of water, the action of the atmosphere, and, probably, also that of fire and other agents, have reduced the quartz to fragments, which have subsequently acquired a rounded form by rubbing against each other, in consequence of the motion communicated to them by the air and water.

Sand is divided into three principal varieties, distinguished from each other by the size and transparency of the grains.

(*a*) *River sand* is composed of fine, clear, colorless grains; it is generally deposited by springs and rivers.

(*b*) *Pearl sand* is composed of large, round, semi-transparent grains. It is very frequently found below the surface of the ground. It is likewise washed up and deposited by running water.

(*c*) *Moving sand*. The grains of this kind are of various sizes. It is mixed with various heterogeneous matters, and generally carries alumina, and, some-

* Common felspar is composed of—

	Parts.
Silica	62·82
Alumina	17·02
Lime	3·00
Oxide of iron	1·00
Potash	13·00
Loss	3·50
	= 100

† Common mica is composed of—

	Parts.
Silica	47·00
Alumina	20·00
Oxide of iron	15·55
Oxide of manganese	1·70
Potash	14·35
Loss	1·20
	= 100

times, also lime, along with it. It is easily moved by the wind, and hence derives its name. It is frequently heaped up in valleys by currents of air and water, or collected in large quantities at the base of some obstacle. These heaps, if not united at the surface by the roots of plants growing on them, or by a certain portion of vegetable mould, are often carried away by the wind, and cause great damage to fertile meadows and plains on to which they are drifted.

Below the surface of the ground, sand is found in veins, or elongated strata, between other layers of earth. It is to these beds of sand that we are indebted for our purest springs. Water, as it filters through them, deposits the heterogeneous matters which it contains, and increases in clearness during the whole of its course.

Although the grains of sand are, for the most part, composed of silica, they always contain small portions of alumina and oxide of iron. Sand has as little attraction for water as pure silica; and thence, as well as from the circumstance of its not having the attraction of cohesion for humus, arises the sterility that attends soil composed in too large proportions of that earth. When the sand is united into hard masses by adhesive matter, such as clay or lime, or by mechanical compression, it is called *sand-stone*. There are various kinds of this substance, all differing from one another in fineness and in density. They are taken out of the ground in a soft state, and cut for building purposes, to make door-jambs and window-sills; also, mill-stones, and wheels for grinding polishing-tools, are made from them. To this class also belong filtering-stones, which allow water to pass through them like a sponge, and are, therefore, used to purify muddy water. This sand-stone was formerly scarce; but abundant quantities of it are now found in Saxony and in other countries.

ALUMINA.

This simple earth is mostly contained in the compound mass, called *potter's earth* or *clay*. Hence the ancient name of argillaceous earth is derived; but, as it is one of the most essential constituents of a salt known by the name of *alum*, modern chemists have thought proper to give it the appellation by which it is at present distinguished. It is composed of a metallic basis, called aluminum, united with oxygen. It must not be confounded with clay, which is a very compound body: clay, of which we shall presently have to speak, is a mixture, in various proportions, of alumina with silica and oxide of iron.

Alumina is the earth which, next to silica, is found most frequently, and in the greatest abundance, in our soils. Clay, into the composition of which alumina always enters, exists, in a greater or less degree, in every soil, and is also found in extensive strata beneath the surface of the earth. Moreover, alumina forms a constituent part of most stones, and in some it is the principal ingredient. Organic substances contain a very small portion of it; and a trifling quantity is found in the ashes of most vegetable substances.

This earth is of great importance to the agriculturist. As a constituent part of clay, it always enters into the composition of vegetable mould. A perfect acquaintance with it is also essential to the agriculturist, in order to enable him duly to appreciate the influence of clay upon his fields, and the improvement or deterioration of soil which it occasions. Clay, likewise, deserves attention on account of its utility in the manufacture of tiles and pottery. All these considerations should induce the agriculturist attentively to study, first, the properties of pure alumina; and, secondly, those of clay.

Although the utility of clay, and its employment in the fabrication of tiles, bricks, and earthenware, have caused it to be known from the very earliest periods, it was not, until very recently, regarded as an elementary substance. It was for a long time confounded with earth in general, and afterwards assimilated sometimes with lime, and at others with silica, and supposed to have acquired an unusual character by the action of acids and other substances. It was not until the middle of the last century that alumina was proved to be a peculiar earth, which ought not to be confounded with others; and it was only at the commencement of the present century that its metallic basis was discovered. Notwithstanding the abundance of alumina, it is never found in nature in a state of absolute purity; it is usually combined with other earths and metallic oxides, and, sometimes, also with acids. In the garden attached to the college at Halle,

white earthy substances were found, which were for a time regarded as pure alumina; but, on the one hand, it was proved, by a more precise chemical analysis, that, although consisting chiefly of alumina, it also contained lime and oxide of iron; and, on the other, it is probable that the substance in question was not a product of Nature, but of the labors of certain alchemists who had resided upon the spot.

It is by chemical processes alone that alumina can be obtained perfectly pure, and separate from all foreign bodies. The easiest and most common method of obtaining it in this state is to prepare it from alum, in which it exists in combination with sulphuric acid. The alum having been dissolved in water, the sulphuric acid is neutralized with an alkali, and the alum precipitated. Certain other processes are, however, necessary to purify it completely from the heterogeneous substances with which it is mixed.

Alumina is incapable of combining with carbonic acid, or, at all events, of forming a solid compound with it, as is the case with lime and magnesia; and this property particularly distinguishes it from magnesia. Several authors have, undoubtedly, spoken of the combination of alumina with carbonic acid; but De Saussure has shown that, chemically, pure alumina has not the slightest affinity for carbonic acid.

The physical properties of this earth are varied, to a certain extent, by the means which are taken to separate it from the substances with which it is united, and by the quantity and quality of the agents employed. Properties appertaining to clay have frequently been ascribed to alumina; and hence, undoubtedly, have arisen the variations in the accounts which different chemists have given of it. These discrepancies are not, however, of sufficient magnitude to cause alumina to be confounded with other earths.

It is a white pulverulent substance, and soft to the touch: it has, properly speaking, no taste; but, when placed on the tongue, causes a peculiar sensation, arising from the absorption of moisture. The peculiar odor given out by crude clay, especially when moistened by breathing upon it or in any other manner, is not characteristic of pure alumina; and those who have considered it to be so are in error.

Alumina appears to have a greater affinity for water than any of the other elementary earths, since it retains a greater quantity of it; it likewise contracts a much stronger mechanical cohesion with this fluid than the others. But this latter property is found to differ considerably in the various preparations that are made with alumina. When it has been recently precipitated, it often contains, before it is dried, a quantity of water equal to six times its own weight; whereas, after having been dried at a moderate heat, it is incapable of retaining more than one and a half times, or, at most, twice its own weight, without dropping. When it has been made red hot, or even dried at a very high temperature, it becomes incapable of retaining more than a very small portion of water.

Alumina, when moistened with water, forms a paste possessing more or less of an unctuous character; but this paste, when made with pure alumina, is never so ductile as that which is formed of crude clay, neither does it receive any shape which may appear desirable to give it with the same facility.

This earth is insoluble in pure water. When it is mixed with a large quantity of that fluid, the particles, being separated to a considerable distance from one another, appear to be semi-transparent; it becomes divided into extremely small molecules, which fall very slowly to the bottom of the vessel—the water not retaining the smallest quantity in solution. But if we impregnate that fluid with carbonic acid, it is, according to De Saussure, then capable of dissolving a small quantity of the alumina; this combination is, however, so feeble, that it soon decomposes when exposed to the air—the liquid, which was at first limpid, becoming turbid, and depositing the alumina at the bottom of the vessel, in the form of a light gelatinous sediment.

At a gentle heat of about 18 or 20 degrees of Reaumur,* alumina allows the water, which is imperfectly united with it, to evaporate; but this degree of temperature is not sufficient to deprive it of all the fluid it contains—which, according to Buchholtz, amounts to 28 per cent. of the weight of the earth, and, ac-

* From 22 deg. 50 m. to 25 deg. of the centigrade. [*French Trans.*
From 72½ deg. to 77 deg. of Fahrenheit.

cording to De Saussure, to a considerably greater quantity. A very intense heat is required to effect an entire separation of the water from it.

Alumina is infusible at all ordinary temperatures; but in the focus of a large burning mirror, or in a fire fed by a stream of pure oxygen gas, it undergoes a species of fusion, which does not, however, produce a complete vitrification.—When mixed with lime, it may be completely fused; and, when united to silica, its tendency to fusion is increased. Incandescence, however, always causes a very considerable alteration in its properties: the effect produced is not exactly that of fusion, but a kind of coagulation; the alumina loses the cohesive attraction for water, and becomes hard to the touch; when mixed with that fluid it no longer forms an unctuous paste, and, upon the whole, approximates more nearly in its properties to silica. Hence it happens that clay partly loses the ductility by the action of the fire. This, also, in some measure, explains to us the good effects that are produced by burning argillaceous soils. Alumina, which has been made red hot, can only be restored to the primitive state by dissolving it in acids, and then precipitating by means of an alkali.

The earth in question does not appear to possess any alkaline properties, as it produces no change in the tint of the colored papers which are used as tests for alkalies. It is also incapable of combining with sulphur like the alkalies, lime, and magnesia. We are not acquainted with any direct experiment which proves that alumina, in a state of purity, can enter into combination with oxygen, hydrogen, nitrogen, or carbon; it is, nevertheless, probable that it has an affinity for these substances; at all events, it has an affinity for their compounds, as is seen in the humus.

On the other hand, alumina has a very powerful affinity for the other earths, and, in certain cases, enters readily into chemical combination with them. It has a very great tendency to unite with silica, and, according to Guyton, can even precipitate that substance from its solution in an alkali. It is in consequence of this affinity that we so often find silica in nature combined with alumina in forming the compound called clay.

Lime, also, has a strong affinity for alumina. This explains the great fusibility of these earths when mixed, and still more clearly proves the power of alumina to decompose lime-water, and separate the lime from its solution. If recently precipitated alumina be thrown into lime-water, the liquid loses the alkaline taste, and the alumina falls to the bottom of the vessel, carrying the lime along with it. This separation of the latter can only result from the chemical affinity of the alumina for it, and from an actual combination of the two earths.

Alumina is easily dissolved in acids when it has been only partially dried; but, after having been ignited, the dissolution is attended with greater difficulty.—The solution takes place without effervescence or any rise of temperature. But this earth does not possess the power of depriving acids of all their acidity, and of wholly neutralizing them; and in this respect it differs essentially from the alkalies and alkaline earths. The solutions have an astringent taste, and communicate a reddish tint to blue litmus paper. The results of compounds of alumina with acids are salts, some of which are crystallizable, and others are not; but most of them are easily soluble in water. Alumina has a strong affinity for sulphuric acid, in combination with which it forms a viscous substance, which soon becomes moist when exposed to the air; if a little potassa is added to this compound, alum is formed. This earth may, however, contain a small portion of sulphuric acid without forming a saline compound; it is on this account that it is often difficult to effect a complete separation between these two bodies. When precipitated from a solution of alum, the alumina carries with it a small quantity of sulphuric acid, from which it can only be purified by repeated washings.

The muriatic, nitric and phosphoric acids do not form crystallizable salts when brought into combination with alumina; most of them, on the contrary, produce viscous solutions.

The alkalies exert an action on alumina which it is very important to notice, both because it may serve as a distinguishing characteristic of this earth, and because it is frequently resorted to for the purpose of separating alumina from other substances. Lime and magnesia are not operated upon by pure alkalies, whereas alumina is completely dissolved by them. The combination takes place

the more easily, in proportion as the alumina has been more recently precipitated, and contains a greater quantity of moisture; and it is very difficult to effect it when the earth has been previously ignited.

Ammonia will disclose a very small quantity of alumina, but potassa and soda dissolve a much greater portion of it and with much greater rapidity. When moistened alumina is thrown into a warm, caustic, alkaline lye, it dissolves, and the liquid becomes transparent; but when the alkalies are completely saturated with carbonic acid, they no longer dissolve this earth.

All the alkalies, together with lime and magnesia, have a stronger affinity for acids than alumina possesses; they may, therefore, be used to separate the latter from its combinations. Thus, for example, the solution of alumina in an alkali is immediately decomposed by the addition of an acid; and the alumina itself is precipitated from its solution in an acid by the addition of any of the alkalies, the affinity of which for acids is greater than that of alumina.

CLAY.

Clay, as we have already observed is a compound of silica and alumina. These two earths are not merely mingled together in it, as is generally supposed, but chemically combined. A large proportion of the clay found in nature is also mixed with an extra quantity of silica, which exists in it in the form of sand of various degrees of fineness. This sand may, however, be separated from it by simple washing, or by a mode which experiment has lately shown to be much better, by boiling the mixture in water; but that portion of silica which is in direct combination with the alumina can only be separated by the action of chemical re-agents. Clay not only differs in appearance both from silica and alumina, but even its properties do not correspond in that degree which might be expected from the proportion in which these two substances are united in it. It has peculiar properties which a mechanical mixture of silica and alumina cannot be made to exhibit. Nature seems, indeed, to have reserved to herself the power of effecting this intimate union; for, although means have been discovered of effecting the combination of silica and alumina by chemical processes, the compound thus formed does not constitute a true clay.

Clay always contains iron in a higher or a lower state of oxidation; and it is probable that this metal constitutes an essential part of it. Oxide of iron is formed by the union of the metal with oxygen, and this combination is easily effected by the action of moisture. The colors of the oxide vary, according to the degree of oxidation, from black to yellow, brown, and red; the black tint indicates the lowest degree of oxidation, and the red the highest. Oxide of iron is an insipid, inodorous powder, insoluble in water, but easily soluble in acids, and in combination with these latter it forms salts, which have the smell of ink. These ferruginous salts are, in their turn, decomposed by alkalies, because the latter have a superior affinity for acids. Astringent vegetables, or those which contain tannin, such as gall-nuts and oak-bark, separate the iron from the acid; and the precipitated iron being divided into very minute particles, tinges the fluid with a black hue.

Iron is sometimes operated upon in the ground by an acid, generally by carbonic acid, with which it forms an insoluble compound, wholly devoid of taste, and indifferent if not useful to vegetation. Other acids expel the carbonic acid from this compound, causing an effervescence like that produced when an acid is poured upon chalk. This circumstance once led me into error in a superficial examination which I was making on a sample of clay that was supposed to contain marl.

Oxide of iron is sometimes combined with phosphoric acid, especially in marshes, where that acid is produced by the decomposition of organic bodies. This compound is equally insoluble with the last, but it is nevertheless thought to be injurious to vegetation.

When iron is combined in the soil with sulphuric acid, produced by the decomposition of iron-pyrites, it forms the neutral salt commonly called "green vitriol."

This salt, when mixed in a very small proportion of clay, appears always to exert an injurious action upon vegetation; indeed, sulphuric acid has never been found to be favorable to vegetation excepting upon calcareous soils, in which the

acid immediately combines with lime, and thus forming gypsum, instead of being united with iron.

It is only when combined with vegetable mould, or other substances containing large quantities of carbon, and even then used in very small quantities, that the sulphate of iron (green vitriol) has produced a fertilizing effect, or any great improvement of the soil. We shall enlarge farther on this subject when we come to treat more particularly of manures.

Clay has probably been formed by the decomposition of hard rocks or stones. Many compact minerals, composed of alumina, silica, and oxide of iron, are decomposed by the action of the atmosphere, and transformed into clay; among the principal of these are argillaceous schists, which are frequently met with, aud in some places compose whole mountain chains, and also felspar. This kind of decomposition is constantly going on before our eyes, naked rocks of clay-slate becoming covered with a stratum of clay, in which vegetables speedily take root. This light covering may easily be thickened and increased by separating the layers of the schist by means of a plow, and decomposing them with fresh manure, which seems to have the power of accelerating the disintegration.

The clay formed by this insensible operation of nature was, probably, in former ages, displaced by the action of running water, and deposited in the plains as we see it at present. Besides, it has, according to all appearance, attracted certain substances from the atmosphere, particularly oxygen.

The three substances of which clay is chiefly composed, viz., alumina, silica, and oxide of iron, are united in it in very different proportions, and we seldom find two kinds of clay exactly the same composition. In the greater number of cases, silica is the predominating ingredient; the quantity of this substance frequently amounts to 93 parts in 100 without the mixture losing the properties of clay. Alumina very rarely forms the principal conponent part.

From the results of recent experiments made in our laboratory, we have found that clay which has been freed from sand by washing the silica, is still found to exist in two different states. First, when this clay is boiled for a considerable time and in a sufficient quantity of water, it deposits a kind of silica which certainly cannot be called sand, but which is nevertheless composed of grains even less minute than those which are precipitated from a solution of flints. The quantity of this silica which can be thrown off by ebullition, varies in different kinds of clay, and cannot be separated from them without great difficulty; and even when the separation has been effected with all possible care, there still remains a large quantity of silica in the clay, which can only be got rid of by chemical re-agents. We are still carefully prosecuting these researches, principally with the view of arriving at some positive conclusion with respect to a fact which at present we consider probable; viz., that all kinds of clay, when freed from that portion of silica which is united with them by a less intimate and merely in a mechanical combination, contain equal or nearly equivalent, portions of that earth and alumina.

The quantity of oxide of iron contained in clay varies from one to ten or twelve parts in a hundred.

Sometimes clay contains oxide of manganese also; but this substance is rarely met with, and only in small quantities.

Clay is not always of one color: it is found to be white, grey, brown, red, black, and in all the various shades of these colors. Sometimes the variations are chiefly attributable to combustible matters, such as humus, and to a kind of bituminous substance; these latter communicate to the clay a grey tint, inclining to black, and sometimes make it quite black. But such clays, when submitted to the action of fire, become perfectly white; because, during this action, the carbon combines with oxygen, and escapes in the form of carbonic acid. The colors, however, mostly arise from the presence of oxide of iron, and sometimes, also, from that of oxide of manganese; the different shades depending partly upon the relative quantities of these substances contained in the clay, and partly upon the degrees of oxidation. The color approaches the more nearly to bright yellow, deep yellow, or red, as the iron may be in a higher state of oxidation. Clays of this description do not become white when ignited; on the contrary, the oxide of iron which they contain takes up an additional quantity of oxygen—the iron becoming peroxidized—and the color then changes to brick-red. All clays which

contain from four to six parts in a hundred of oxide of iron, acquire this tint by ignition—the depth of the color increasing in proportion to the quantity of oxide that is present.

Sometimes the clay derives the color from the joint presence of oxide of iron, vegetable mould, and of bituminous substances. Clays of this kind acquire a lighter color by ignition, because the vegetable matter from which their color partly arises is volatilized; but they never become perfectly white, because the oxide of iron, which is also concerned in the production of the color, remains behind. The loss of color which these clays experience from ignition depends, therefore, upon the relative quantities of oxide of iron and of combustible matter which they contain: where the color is very materially diminished in intensity, we may conclude that it was chiefly produced by the presence of combustible matters; if the contrary, that it arose principally from oxide of iron. Clays are sometimes found which are perfectly white, and these do not contain any inflammable substances. They are not, however, wholly free from oxide of iron, but the substance is present in the lowest degree of oxidation, and incapable of communicating any tint whatever to the clay. If, however, clays of this description are exposed to a white heat, the iron becomes more highly oxidized, and the clay acquires a yellow, and sometimes a bright red tint. Should any white clays not change the color when exposed to the action of fire, we may venture to conclude that they contain a very small quantity of iron.

Clay possesses the property of exciting a peculiar sensation in the organs of taste and smell in as high a degree, at least, as alumina; and it may thus be easily distinguished from other earths. When powdered and introduced into the nose, or applied to the tongue, it absorbs the moisture from the organ to which it is applied, and adheres firmly to it. Clay has, moreover, a peculiar odor not possessed by alumina, and which is called *earthy*. This is exhaled very copiously when clay which has been dry for some time is moistened; and hence the odor which generally pervades the atmosphere when rain falls after a drouth.—De Saussure attributes this effect to oxide of iron, but it is given out as strongly by clays which contain a small portion of that oxide as by those which contain it in much greater abundance. It is, at present, a doubtful point whether this odor is exhaled by the clay, or is the consequence of some peculiar change in the atmosphere which surrounds it.

Among the properties of clay, none are so remarkable as their relations to water. When in a state of comparative dryness, although not absolutely free from moisture, it absorbs water with facility; and when it contains a considerable quantity of that fluid, it forms a more or less tenacious, adhesive, and ductile mass, which easily takes and retains any impression that may be given it, and is, therefore, capable of being moulded into all sorts of shapes. The property in question, which renders this kind of earth so useful, is not possessed in the same degree by all clays; those which possess it in the greatest perfection are called fat or soft clays, and those which have it in a less degree poor clays. The plastic nature of this substance ought not to be attributed solely to the presence of alumina, for that earth in its pure state does not possess these qualities in so high a degree; they seem rather to result from the combination of alumina with silica, and even the oxide of iron seems to be partly concerned in their production. It is true that the fattest and most ductile clay contains the largest portion of alumina, and the brittle or poor clay the least quantity; but the degree of ductility is, nevertheless, not in exact proportion with the quantity of this earth which is present.

Clay, when saturated with water, is no longer pervious to that fluid. When water is poured upon a cake or basin made with clay paste, it remains on the surface without filtering through it. This faculty imparts great importance to the presence of clay in the upper stratum of the soil, and even to those which are underneath. It is the clay thus situated which prevents water from penetrating to a greater depth; were it not for this stoppage we should not meet with any springs without boring down to the solid rock. These beds of clay, alternating with strata of earth permeable to water, are the most ordinary source of springs, because the water retained by them can only force a passage for itself in a direction parallel with them. These beds are also the cause of those swamps, or collections of stagnant water, which are sometimes met with in fields

and plains; the water, not being able to penetrate into the earth, remains on the top of the clay strata until it is thoroughly evaporated, and thus shows itself on the surface of the ground.

When clay is macerated in a large quantity of water, it renders that fluid turbid, and remains suspended in it, but the water does not dissolve the smallest portion. A considerable time elapses before this fluid again becomes completely limpid. It is in consequence of this property that the water of rivers whose beds are composed of clay is always more or less turbid; the detached and finely-divided particles of the clay not being able to settle at the bottom, by reason of the constant motion of the stream. It is also from the same cause that lands inundated by rivers which have burst their banks are generally covered with clay; for the sand which the waters carry with them, being heavier, quickly sinks to the bottom, and is deposited at random in heaps; while the clay, being very minutely divided, and, as it were, diffused through the mass of water, is carried to a greater distance, and not deposited until the water has become stagnant.*

When clay is exposed to frost, cracks or fissures are formed in it; indeed, it is sometimes completely disintegrated. This separation of masses of clay and com-

* All the earths found in cultivated soils have a very considerable attraction for atmospheric moisture; and when they are mixed with organic decomposing substances, or pulverized, this power is materially increased. This property of the soils he cultivates cannot be too carefully kept in view by the farmer. It is one of the chief reasons why fallowing, deep plowing or subsoiling are so fertilizing in their effects; and why plants, growing on cultivated soils, are able to maintain themselves in health, even in the dryest seasons.—The extent of this attractive property of the earths and soils may be ascertained, experimentally, by either exposing a given weight of the previously well-dried earth to a moist atmosphere for a stated period, and then weighing it again to discover the amount of the moisture absorbed; or else, by confining a given portion of the dried earth in a confined portion of air, and then, by the hygrometer, determining the degree of dryness which has been produced by the earth confined in it.

In the experiments of Professor Leslie, made with a very delicate hygrometer, when thoroughly dried garden mould, introduced into a confined portion of air, saturated with moisture, indicated a dryness of 95 degrees,

The same weight of alumina, under the same circumstances, indicated a dryness of...	84 degrees.
Carbonate of magnesia	75 "
Carbonate of lime	70 "
Pipe-clay	85 "
Shelly sea-sand	70 "
Greenstone resolved into soil	92 "
Silica	40 "

In my own experiments with various earths and soils, the specimen was previously dried in a temperature of 212°, and then exposed to air saturated with moisture, at 60°, for three hours—under these circumstances:

1,000 parts of clay	gained	29 parts.
1,000 " coal ashes	"	14 "
1,000 " lime	"	11 "
1,000 parts of gypsum	gained	9 parts.
1,000 " chalk	"	4 "

And when exposed for eighteen hours to air at the temperature of 62° ("Essay on Salt," p. 7)—

1,000 parts of rich soil, near Maldon, in Essex, worth two guineas an acre, gained	25 parts.
1,000 parts of the same field, which had been salted with 12 bushels of salt per acre, gained	27 "
1,000, which had been salted with 6 bushels per acre, gained	26 "

In the experiments of Professor Schubler, the amount of the moisture absorbed by the earths was ascertained at four different periods, viz. 12, 24, 48, and 72 hours; the temperature of the atmosphere in which they were exposed was between 59 and 65° ("Journal English Ag. Soc." vol. i. p. 196), and each earth was spread over a surface of fifty square inches. The amount absorbed is stated in grains:

1,000 grains of	12 *hours.*	24 *hrs.*	48 *hrs.*	72 *hrs.*
Silicious sand	0	0	0	0
Calcareous sand	2	3	3	3
Gypsum powder	1	1	1	1
Sandy clay	21	26	28	28
Loamy clay	25	30	34	35
Stiff clay	30	36	40	41
Grey pure clay	37	42	48	49
Fine lime	26	31	35	35
Fine magnesia	69	76	80	82
Garden mould	35	45	50	52
Arable soil	16	22	23	23
Slaty marl	24	29	32	33

Davy saw this property of all soils in its true light. "The soils," he said, "that are the most efficient in supplying the plant with water, by atmospheric absorption, are those in which there is a due mixture of sand, finely-divided clay, and carbonate of lime, (chalk,) with some animal or vegetable matter; and which are so loose and light as to be freely permeable to the atmosphere. With respect to this quality, carbonate of lime and animal and vegetable matter are of great use in soils; they give absorbent power to the soil, without giving it tenacity. Sand, on the contrary, which also destroys tenacity, gives little absorbent power. I have compared the absorbent power of many soils with respect to atmospheric moisture, and I have always found it greatest in the most fertile soils; so that it affords one method of judging of the productiveness of land."

1,000 parts of a celebrated soil, from Ormiston in East Lothian, when dried at a temperature of 212°, gained in an hour, by exposure to air saturated with moisture at temperature 62°, 18 parts. 1,000 parts of a very fertile soil from the banks of the river Parrett, in Somersetshire, under the same circumstances, gained 16 parts. 1,000 parts of a soil from Mersea, in Essex, worth 45*s.* an acre, gained 23 parts. 1,000 parts of a fine sand from Essex, worth 28*s.* an acre, gained 11 parts. 1,000 parts of a coarse sand, worth 15*s.* an acre, gained 8 parts. 1,000 parts of the soil of Bagshot Heath gained only three parts.—("Elements of Agricultural Chemistry," 183.)

It is evident, therefore, that the power of absorbing moisture is, in a great degree, the measure of the fertility of all soils.

The quantity of water required to thoroughly saturate the various earths is also a question of considerable importance to the farmer. This has been recently determined experimentally by M. Schubler, whose work

minution of their parts, is caused by the expansion which water undergoes in freezing, in which the crystals or needles of ice separate the particles of clay one from the other. On this account clay which is to be used for the purpose of improving and ameliorating land, is always first submitted to the action of frost, in order that by the perfect comminution and division of the particles, it may be better adapted for mixing and amalgamating with the soil on which it is laid.

Moistened clay, even when subjected to the action of heat, parts with the water with very great reluctance, and the more so in proportion to its fatness; and it retains that fluid more tenaciously than any other earth. After the evaporation of the water it becomes more or less hard, according as it is rich or poor. Moist clay, when exposed to a high degree of heat, often breaks and falls to pieces; the vapor, by its elastic power, opening a passage for itself, and breaking the substance in which it is enclosed. This is the reason that, in making tiles, it is necessary to dry them first by exposure to the air, and then to heat them gradually in the kiln.

Clay, in drying, always contracts and loses a portion of its bulk. This contraction arises from the evaporation of the water, in consequence of which the particles of clay approach each other more closely; and this quality produces the fissures which, during very hot and dry weather, are formed on the surface of argillaceous soils. The same circumstance also renders it necessary to model

on this subject has been translated by James Hudson, Esq. the excellent Secretary to the English Agricultural Society. The following table shows the result of the German Professor's researches ("Journal Eng. Agri." vol. i. p. 184):

	Real quantity of water in a cubic foot when saturated.	*When dry.*	*Weight of a cubic foot when saturated with water*
Calcareous sand*	31·8 lbs.	113 6 lbs.	141·3 lbs.
Silicious sand	27·3	111·3	136·1
Gypsum powder	27·4	91·9	127 6
Sandy clay	38·8	97 8	129·7
Loamy clay	41 4	88·5	124·1
Stiff clay, or brick earth	45·4	80·3	119·6
Pure grey clay	48·3	75·2	115·8
Pipe clay	47·4	47 9	102·1
The carbonate of lime	47·5	53·7	103·5
Fine carbonate of magnesia	62·6	15·8	76·3
Garden mould	48·4	68·7	102·7
Arable soil	40·8	84·5	119·1
Fine slaty marl	35·6	112·0	140·3

Another important property of soils to be considered by the farmer, when he is endeavoring to improve the composition of his land by an admixture of earths, is the property which these possess of retaining their moisture when exposed to the action of the atmosphere. This property has also been examined by Professor Schubler, and his experiments are very valuable to the cultivator as comparative results; otherwise, experiments of this kind, carried on in a close room, always differ very materially in the amount of evaporation from that of the same soil in situations exposed to the wind and sun. The mode adopted in these experiments was as follows (*Ibid.* p. 109):—"We place on a round surface of tin plate, having a raised border, a given quantity of the earth to be examined. Having previously saturated this fully with water, we spread it out evenly, and ascertain the weight of the whole; we suffer it to remain for several hours in a close room to evaporate, and again weigh it, to ascertain the quantity of water evaporated. If we make the experiment with many earths at once, we shall be able to institute a comparison among them with the greatest certainty in reference to this point. To obtain accurately the quantity of water contained in the earth at the commencement of the experiment, we afterward dry it in an artificial heat, and thus easily reduce the quantity of evaporated water to hundredth parts of that contained in the earth.

Let the weight of a wet earth be	310 grains.
The weight of the same earth after 24 hours	260
The weight of the perfectly dry earth	200
Therefore, the amount of water evaporated in 24 hours will be	50
And the water in the earth at the beginning of the experiment	110

The following table contains the results of my experiments, in reference to this point, with 200 grains of the several earths, at a temperature of 65½°, spread out over a surface of ten square inches; and, in stating the results of all these experiments, the quantity of evaporation is given, as from every 100 parts of water contained in the earth.

Silicious sand	evaporation in 4 hours,		88·4	Pure grey clay	evaporation in 4 hours,		31·9
Calcareous sand	"	"	75·9	Fine lime	"	"	28·0
Gypsum powder	"	"	71·7	Magnesia	"	"	10·8
Sandy clay	"	"	52 0	Garden mould	"	"	24·3
Loamy clay	"	"	45·7	Arable soil	"	"	32·0
Stiff clay, or brick earth	"	"	34·9	Slaty marl	"	"	68·0

This reluctance to part with the moisture with which the soil is combined increases, the cultivator is well aware, with the tenacity of his land; his experience in this respect agrees entirely with the experiments of Professor Schubler. [*Johnson on the Fertilizers*, p. 264.

* The reason why the real quantity of moisture in a soil cannot be accurately determined by merely comparing the weight of a given measure when dry, with the same measure when wet, is, that some soils when they are dried materially contract, and expand when wet, as every cultivator of a clay soil can attest.

tiles and earthenware vessels one size larger than that which is required after baking.

Clay can only be completely deprived of moisture when heated to a bright red heat; it then contracts still farther, and undergoes a kind of condensation which brings the particles still more closely together. The terms of "shrinking" and "contraction" are used to denote this approximation of the particles of clay occasioned by the action of heat, to which rich clays are more exposed than those of inferior quality.

But the contraction of any particular kind of clay is always the same when subjected to a definite degree of heat; or, in other words, when it is submitted to any one particular temperature, the clay will always experience a similar diminution of volume. This property has introduced clay in the construction of pyrometers for measuring very high temperatures.

Clay does not fuse with the heat of an ordinary coal fire; but when the fire is strongly increased by a bellows, or fed with oxygen gas, the fusion takes place. The addition of lime greatly augments the fusibility of clay, and the same effect is produced by oxide of iron. Hence, a large addition of lime or of oxide of iron in the fabrication of bricks and of earthenware is very injurious, because, as frequently happens, the bricks or vessels so formed melt and fall to pieces when the temperature of the furnace is very high. But in small quantities these substances may be of service, as they induce the commencement of vitrification, a greater condensation of the particles, and, consequently, an increase of solidity in the mass.

The properties of clay which has been heated to redness, differ greatly from those of the same substance in its natural state. The fragments of the former are often sufficiently hard to give out sparks when struck with steel, and cannot be softened by immersion in water. When pulverized and mixed with that fluid, they no longer form an adhesive, unctuous, and ductile paste, but the powder allows water to pass through it, retaining a very small quantity, and then it resembles sand or silica. No artificial process can restore that ductility to baked clay which it previously possessed; nevertheless the action of the atmosphere, of moisture, and of animal manures, seem to bring it back by degrees to the natural and original state.

Generally speaking, air appears to exercise a very powerful influence on clay, whether baked or unbaked. This action is peculiarly apparent in the beneficial effect produced upon land by clay which has been exposed to the air for a long time. It is generally known that the earth of old walls and ovens forms an excellent manure, and increases the fertility of the soil.

It was formerly thought that clay absorbed the nitre contained in the air. It has, indeed, been ascertained that it favors the formation of nitrate of potassa in saltpetre houses; but the atmosphere never contains nitre ready formed. Various observations and experiments, however, tend to induce the belief that clay, when exposed to the air, absorbs nitrogen, hydrogen, and all the other animal exhalations contained in the atmosphere. When kneaded, clay is exposed for a considerable period in large masses, and in a damp situation it assumes all the characters of putrefaction. Ammonia is then formed in it, thus proving the presence of nitrogen, which is a constituent portion of ammonia.

Even if it has not yet been proved that pure alumina absorbs oxygen from the atmosphere, there is no doubt of that property being possessed by clay. Humboldt has satisfactorily ascertained its existence in all the kinds of clay which he has examined, and even in compact slate.

The absorption of various substances, both known and unknown, from the atmosphere, renders clay lighter, thinner, and less tenacious. This fact is established by several chemical experiments and analytical examinations. I have analyzed clay taken from the surface of the ground, as well as that taken from a considerable depth; both were found to contain the same proportions of alumina, silica, and oxide of iron, but the former was decidedly poorer than the latter. Since the action of the air renders clay less compact, we can easily understand the cause of the benefit which a very argillaceous soil derives in this respect from the operations of turning it up, plowing, digging it with a spade, &c.; for the upper stratum of the soil is thus brought into contact with the atmosphere at a greater number of points, the air is enabled to penetrate more deeply into the

ground, and convey a large quantity of those substances which it contains; and thus the soil is rendered lighter, and a more complete separation of its parts is effected.

Acids exert little action upon those clays which are free from lime. They do not produce any effervescence unless a large quantity of carbonate of iron is present. Alumina and oxide of iron certainly are, when in a free state, easily soluble by acids; but, when mixed in clay, they are protected from the influence of these substances by the silica with which they are surrounded or united. Acids, when poured upon clay, undoubtedly dissolve a portion of these component parts, but not the whole of them. The quantity dissolved is greater in proportion as these substances predominate over the silica. Thus, a rich clay will give a larger portion of alumina to an acid than a poor one. Acids will also absorb a larger quantity of oxide of iron from a clay which is rich in that metallic body than from one which contains little of it. This accounts for the fact that land which contains a considerable quantity of oxide of iron is, in consequence of that very circumstance, inferior in point of fertility to other land which, although similarly constituted in all other respects, contains a smaller portion of this oxide. This substance is not in itself injurious to vegetation, and only becomes so when combined with certain acids. Nevertheless, as acids are easily formed in the ground, and as they more readily operate upon clay which is rich in oxide of iron than on that which contains a small quantity, their deleterious effects must necessarily be more sensible in the former than in the latter kind of soils.

Most acids, then, do not possess the power of completely decomposing clay; that is, of effecting a thorough separation between the alumina and oxide of iron, and the silica. Clay may be boiled in nitric or muriatic acid without the alumina and oxide of iron being completely dissolved. Concentrated sulphuric acid is the only one which is capable of producing an entire solution, and it can only do so when employed in considerable quantities and boiled for a long time in contact with the clay. An easier method of separating the alumina and oxide of iron, is to mix the clay with an alkali (caustic alkalies answer the purpose best) and expose the mixture to a red heat, when a quantity of acid sufficient not only to saturate the alkali, but also to leave an excess of it, must then be poured upon the fused mass. This excess of acid soon dissolves the alumina and oxide of iron, and the silica may then be completely separated. The alkali seems to diminish the attraction of cohesion between the silica and the oxide of iron, and to weaken the resistance which this oxide, when mixed with alumina, opposes to the action of acids. This process is the surest and the easiest way of decomposing clay.

Besides those bodies which belong essentially to clay, viz: silica, alumina, and oxide of iron, we frequently find other substances in a state either of mixture or of combination.

Clay generally contains sand in fine grains, which cannot be completely removed by ebullition; and it is also frequently mixed in greater or less quantities with a coarse kind of sand, which is easily separated from it by washing. This mixture is called argillaceous earth. We shall have occasion to mention it again presently. Humus, or vegetable mould, is often found in clay, and appears to be rather combined than simply mixed with it. All clays which lie on the surface of the land, or at a small depth below it, contain more or less of this substance. We have found a very considerable quantity of it in clay which was five toises below the surface. Clay is often accompanied by lime in countries where that substance is very plentiful; indeed, it is oftener found united with this earth than without it. Sometimes the lime is mixed with it in small pieces, and it is then easily distinguishable by sight; in other cases these substances are so combined together that the lime can only be detected by chemical analysis. Lime is also found in clay, in a state of union with sulphuric acid, in the form of gypsum or the sulphate of lime. When the quantity of lime contained in clay reaches a certain proportion, the combination is distinguished by the name of marl, a substance which we shall hereafter examine more particularly.

The physical properties of clay, the ductility and power of retaining water, may be greatly modified by these combinations, and in proportion to the quantities in which these substances are mixed with it. Clay, mingled with coarse silica, sand, vegetable mould, and lime, diffuses itself more easily through water,

retains a less quantity of that fluid, dries more rapidly, and does not harden so much as pure clay. When moistened, it is also less unctuous and ductile.

The quantities in which these substances combine with clay are subject to infinite variation; hence, also, the properties of clay itself are infinitely variable. In addition to this fact, it must be observed that, as the essential and constituent parts of clay, viz., alumina, silica, and of oxide of iron, influence the physical properties, there must, necessarily, be an endless variety of clays, all of which —at least as far as composition goes—may be regarded as pure. It is, therefore, impossible to arrange these different kinds in any definite classification, because the several varieties are not marked by any distinguishing characteristics, there being, on the contrary, an endless variety of gradations from the richest kind of clay to the poorest. We shall, however, distinguish some of the most remarkable by particular names, and describe their most essential properties, because a knowledge of them may be interesting to agriculturists as well as useful in thereby enabling them to derive the greatest possible profit from the land at their disposal.

The *kaolin* or porcelain earth is the purest and finest of all the clays, and is the variety employed in the fabrication of fine porcelain. It is found in different countries: in Germany, near to Aue in the Hartz mountains; near to Giehren, Strablow, Teichenau and Tarnorwits, in Silesia; near to Grunnerits in the circle of Saal; near to Vienna in Austria, Passau, Hochst, &c.

Kaolin has probably been formed by the decomposition of felspar. It is of a white, or greyish white, or yellowish white color, sometimes even inclining to red: it falls to powder spontaneously when immersed in water; when pounded in a dry state it forms a powder which, although dry, is soft to the touch and adheres slightly to the tongue: it is sometimes found mingled with particles of lime and mica. The proportions of their constituent parts vary much. According to Wedgewood, the kaolin found in Cornwall contains sixty parts in a hundred of alumina, and twenty parts in a hundred of silica; other varieties contain smaller portions of these constituent parts. It does not contain either iron or the oxide in large quantities.

Good porcelain is also obtained by mixing together certain proportions of different kinds of clay.

Pipe-clay is employed chiefly in the manufacture of pipes for smoking. Next to kaolin, it has, of all kinds of clay, the purest color; its shades and hues, however, vary considerably; it is found white, grey, inclining to blue, and even black; and often contains combustible matters, which give to it a deeper hue. When heated in the fire it becomes white; sometimes, however, preserving a reddish tint. It falls to pieces in water, and does not acquire any great degree of tenacity by uniting with that fluid. Various qualities of it are met with: that found near Cologne is reckoned among the best; that from the environs of Maestrecht the next in quality; but very good pipe-clay is also found near Buntzlau and Plauen; likewise at Weissensprünck in the Electoral March, and in Hesse, Wurtemberg, &c.

Bole is one of the fattest of all the clays: it is manufactured into little tables, which, when stamped, are sold under the name of sealing-earth (*seigel-erde.*) Its color is tile-red, brown, and occasionally pure white. The Armenian bole is generally considered to be one of the best and most valuable of all the varieties. This kind of clay is very soft to the touch: when mixed and united with water, it forms a very tenacious and unctuous paste. It dries and becomes exceedingly hard when exposed first to the air, and then to the action of the fire. White bole acquires, from ignition, a yellowish tint, or a color slightly inclining to red.

Blood-stone or *red ochreous clay* is a kind of bole which is very rich in oxide of iron. It is found in various places; but that which comes from Striegau, Zittau, and Neuremberg, is the best in Germany.

Potter's-clay or *tile-clay* derives its name from the use which is made of it in the manufacture of tiles and common earthenware. In flat countries it is found in abundant and extensive strata. It is very tenacious and unctuous, but, nevertheless, often contains a small quantity of sand and lime. It is soft to the touch, and if placed on the tongue adheres firmly to it. It possesses in an eminent degree the power of absorbing water, but does not fall to powder on being immersed in that fluid, but becomes, on the contrary, very tenacious and ductile.

It becomes very much hardened by drying, and has a great tendency to split. When ignited, it is rendered as hard as stone, and it can then no longer be pulverized by rubbing between the fingers; or, indeed, in any way without considerable difficulty.

Fuller's-earth is a poor clay, used for the purpose of removing dirt or grease from cloth, &c. It was formerly imagined that this substance was not to be found any where except in England; but it is now well known that many kinds of clay found in Germany, are equally well adapted for the purposes just mentioned. The exportation of Hampshire fuller's-earth was formerly forbidden in England.

Fuller's-earth is friable; it soon falls to powder in water, without, however, becoming much divided, or forming a mixture like the plastic mass used in pottery. English fuller's-earth is brown, and intersected with yellowish veins; after ignition it assumes a black tint, which it again loses if the incandescence be long continued.*

The kind of clay which, in the classification of the different soils, I distinguish by the name of *marshy earth*, may, as far as regards the quality and other properties, be assimilated to fuller's-earth. It contains only a small portion of alumina, but equally as much silica, and sometimes also a small portion of lime. The degree of tenacity and adhesiveness possessed by it is very trifling; it is tolerably hard; but, nevertheless, always forms dust; and it breaks without difficulty as soon as it is moistened: so that water courses made in it do not remain open for any long time, but are speedily filled with mud. When it is dry and formed into clods, they easily break and separate themselves after a light rain. I distinguish it from soft or plastic argillaceous earth, because the latter is a mixture of rich or poor clay with coarse-grained silica or chalk.

Clay iron ore, or *marshy ferruginous earth* is, for the most part, composed of clay, and a large proportion of carbonate and phosphate of iron, and which together form a hard mass. Not only the nature of it, but also the phosphate of iron which it contains, renders it very injurious to vegetation, both when it is disposed in strata immediately below the surface of the ground, and when it is partly dissolved and brought into contact with the roots of plants. It is decomposed by long exposure to the atmosphere, and, therefore, can only be used for subterranean structures; at all events, this is the case with many varieties of it. It is very durable under water. The color is either brown or an intermediate hue between deep brown and deep yellow, and it often contains veins of a bluish black tint.

It has sometimes been worked for the extraction of iron, and hence is usually included by mineralogists in the list of iron ores.

When this earth or mineral exists on the surface of the ground, it renders the soil unfit for vegetation of any kind, even pines cannot grow upon it. The only means of rendering such lands available for cultivation, is to dig up the earth to a certain depth: this method has actually been applied on pieces of land of small extent, and often at a very great expense.

LIME.

Lime is one of the most abundant substances in nature; it forms whole mountain chains, and together with other earths and metallic oxides constitutes a great number of minerals. It also exists in large quantities in the bodies of animals, forming the principal ingredient of bones and shells. It likewise forms a constituent part of all vegetables; at all events, it is invariably found in their ashes, and it exists in solution in almost all natural waters.

Lime, till lately, has been regarded as an elementary substance; modern experiments and observations have shown that it is a compound. It is composed, in fact, of a peculiar metal called calcium and oxygen. The frequent occurrence of lime in the bodies of animals, the numerous impressions and petrifactions

* The constituents of fuller's-earth, according to Klaproth, are as follows:—

	Specimen from Reigate, Surrey.	*Specimen from St. Nimptch in Silesia.*
Silica	53.0	48.5
Alumina	10.0	15.5
Lime	0.5	....
Magnesia	1.25	1.5
Oxide of iron	9.75	7.0
Common salt	0.1	....
Water	24.0	25.5
Loss	1.4	2.0
	100.0	100.0

found in calcareous rocks, the evidence by which it is proved that this lime is derived from testaceous animals, and, lastly, the numerous reasons which induce us to believe that organic bodies produce lime—all these considerations, taken collectively, have led naturalists to suppose that lime is a product of organic nature. But this opinion is contradicted by the existence of the substance in question in primitive rocks, and at elevations where neither petrifactions nor impressions of organic bodies are found,

Lime belongs to the class of alkaline earths, and its properties seem to bear a close resemblance to those of the alkalies. It has a strong tendency to combine with acids; and, as it occurs everywhere, we always find it in combination with one or the other of those bodies, except, indeed, in the craters of volcanoes, in which we occasionally meet with lime in a pure state, being robbed of the carbonic acid by the action of heat. The acids with which it is most frequently combined are the carbonic and sulphuric; though we occasionally, but not so often, find it united with the phosphoric, muriatic, boracic, and nitric acids.

Carbonate of lime, also known by the name of *crude lime*, is the base of limestone and chalk, and also forms a constituent part of other minerals. It exists in marl in combination with clay, and in many soils it is found mixed more or less abundantly with clay and sand. It can be separated from every mixture, and, by means of certain artificial processes, may be exhibited in a state of purity.

Pure carbonate of lime is a light, white, insipid, and inodorous powder. According to the most accurate analysis, it is composed of 56 parts in a 100 of pure lime, 40 parts of carbonic acid, and 4 parts of water. This latter portion is essential to it, and forms part of the fundamental constitution, and is not evaporated by a moderate heat; carbonate of lime ceases to be such before it parts with the water. This fluid is not contained by it in a liquid form, but as a solid, and in a state of crystalization.

Carbonate of lime easily mixes with pure water, but does not dissolve in it; and if the fluid is left quiet, the carbonate soon subsides. When mixed with water so as to form a thin paste, and then placed upon a horse-hair seive, it retains a quantity of the fluid equal to half its own weight, but allows it to evaporate even more easily than it escapes from sand. But this substance may also be dissolved in water which is saturated with carbonic acid. In order to effect this solution, it is only necessary to stir the substance repeatedly in the water. The quantity of carbonate dissolved will depend upon the amount of carbonic acid that is contained in the water, and will increase or diminish in exact proportion with it. This compound is called *the solution of carbonate of lime in water impregnated with carbonic acid*. It is frequently met with in nature, and the waters of most springs and especially of those which issue from calcareous mountains, are of this kind.

A solution of lime in an excess of carbonic acid, whether produced by natural or artificial means, is rapidly decomposed, and the carbonate of lime separates from the fluid as soon as the acid is removed. This effect is produced by mere contact with the atmosphere, especially when the water is agitated; and this is, doubtless, the reason that certain waters used for irrigation produce so very much greater an effect upon meadows when they flow over them immediately after issuing from their source, than when they are conducted to a considerable distance, and exposed all the while to the influence of the atmosphere. In the latter case the water which was previously limpid becomes turbid, and deposits the lime which it held in solution.*

When calcareous earth is dissolved in water, it adheres to the vessel which contains it, and forms a crust, or collects in masses, becomes agglomerated, and falls into various shapes. When a solution of lime in an excess of carbonic acid is boiled, the acid escapes yet more rapidly; and this may account for the fact that spring water, when boiled, becomes turbid, and deposits a sediment, which forms a crust round the vessel. This crust is formed by the precipitated carbonate of lime, although many uneducated persons take it for nitre.

* That the portion of saline matters contained in spring water is diminished by being used for the purposes of irrigation, has been proved by the experiments of Dr. H. R. Madden, who found that a gallon of water, "clear as crystal," issuing from the base of the Pentland Hill, contained before passing over a meadow ten grains of common salt, and four grains of carbonate of lime, (chalk,) but after passing over the meadow, a gallon of the same water contained only five grains of common salt and two of carbonate of lime.
[*Trans. High. Soc.*, Vol. viii. p. 687.

Bodies which absorb carbonic acid, also precipitate lime from the water which held it in solution. The caustic alkalies, potassa, soda, and ammonia, instantly produce this effect by uniting with the acid, which dissolve the lime, thus precipitating the latter. The alkalies, even in their ordinary state of carbonate, generally have the same effect, for they are not entirely saturated with carbonic acid.

Carbonate of lime undergoes no change when exposed to the action of moderate heat, except that it parts with some or all of the water which adheres to it, and becomes drier. But when exposed to a violent heat it loses the whole of the water, as well as the carbonic acid; becomes caustic, and acquires alkaline properties. In this state only, lime can be regarded as chemically pure; and it is then called calcined or quick-lime. This substance has in all ages and in all countries been used for the purposes of building. We shall not here attempt to describe the preparation of lime on a large scale, but content ourselves with considering its physical and chemical properties, in order to be enabled to account for all the remarkable phenomena it produces, as well as the effects when it is employed as a manure or as mortar.

Quick or calcined lime has an alkaline, caustic, and very disagreeable taste; and, like the alkalies, it possesses the property of alternating vegetable colors. When fragments of lime in this state are moistened with water, they absorb a considerable quantity of that fluid and yet remain dry. A disengagement of heat is soon observed, which gradually increases; and finally the fragments split, burst asunder, and fall into a very white and light powder, which is soft and dry to the touch. The degree of heat produced by this combination of lime with water sometimes exceeds that of boiling water; and when a considerable quantity of lime is slaked in a dark place, light is frequently emitted.

Even when lime is united with a quantity of water equal to the fourth part of its own weight, it does not then become moistened, but absorbs and solidifies the whole of the fluid, and its own weight is proportionably increased. This solidification of the water affords an explanation of the temperature always attendant on the operation of slaking lime, and formerly all sorts of imaginary causes were assigned to account for this phenomenon. The water absorbed by the lime passes from a liquid to a solid state; and the caloric to which this liquid doubtless owes its fluidity, is set at liberty and escapes. The water which has entered into combination with lime passes into a solid state, and can only be separated from it when that substance is heated to ignition.

Lime that has been slaked may easily be mixed with water, and the union takes place without any farther disengagement of heat. When diffused through a large quantity of water, lime forms a kind of fluid paste; and if the quantity of water be still farther increased, a thin liquid will be formed, known by the name of *milk* or *cream of lime*. Lime when slaked is still caustic, although not to so great a degree as quick-lime; it has an acrid, disagreeable taste, and alters the color of paper stained with vegetable juices from blue to green.

Lime which has been calcined, but not slaked, likewise becomes changed by exposure to the air; its fragments fall to powder more or less quickly in proportion to the degree of humidity contained in the surrounding atmosphere; it absorbs the moisture of the air, and thus becomes slaked of itself, often exhibiting a perceptible increase of temperature. But it also becomes changed in another way, gradually losing its causticity and taste, and becoming unfit to be made into mortar. It also absorbs carbonic acid from the air, and thus gradually repasses to the state of a carbonate, so that it cannot be restored to its former condition unless it be calcined afresh.

The time requisite to effect the passage of quick-lime into a carbonate by exposure to the air depends upon the humidity of the atmosphere, and the quantity of carbonic acid which it contains. The greater the quantity of moisture and of carbonic acid, the more rapidly does the transition take place. Calcined lime does not absorb any carbonic acid from dry air, even when that acid is present in large quantities: moisture is absolutely necessary to bring about a union of these two substances. Calcined lime may, therefore, be kept in a dry place for a considerable time without losing its properties. It is not, however, safe to trust to this method in cases where it is desirable to have the lime perfectly pure, as, for example, when it is to be used as a remedy for swellings on the bodies of animals; it ought, in such cases, to be kept in closely stopped glass vessels.

Calcined lime may be completely dissolved in pure water without the intervention of any other substance, and it does not lose this property even when it has been previously slaked. But a very large quantity of water is necessary in order to dissolve it completely, viz., 780 parts of water to one of lime. In order to effect this solution, it is only necessary to agitate either quick or slaked lime in water. The solution thus formed is called lime water; it is perfectly clear and transparent, and has the alkaline taste of lime. Its effect on vegetable colors is precisely the same as that produced by the solution of an alkali.

When lime-water is exposed to the atmosphere, a white crust forms over its surface, which ultimately becomes so heavy that it falls to the bottom of the vessel and is succeeded by another, until the whole of the lime is precipitated from the solution. The mixture thus formed at the bottom of the vessel is called cream of lime. The effect just mentioned is produced by the absorption of the carbonic acid contained in the air by the lime. This acid combines with the lime, which being thus converted into a carbonate, can no longer be held in solution by the water. Lime-water must, therefore, be kept in tightly stopped glass vessels.

Lime which is completely dissolved in water, and even that which is only mechanically mixed or suspended in that fluid, as is the case in the milk of lime, quickly absorbs carbonic acid, and becomes saturated with it, when it is briskly agitated in that gas. All waters containing carbonic acid are robbed of it by the action of lime; hence it also decomposes a solution of lime in an excess of carbonic acid. Lime is, therefore, one of the best reagents that can be employed for detecting the presence of carbonic acid in liquids or gases. It is by a process somewhat of this nature that the quantity of carbonic acid contained in the atmosphere or in water is determined.

Calcined lime easily combines with sulphur, producing various phenomena, according to the manner in which the combination is effected. When caustic or quick-lime in a state of powder is mixed with powdered sulphur, and this combination is heated to redness, it becomes brown, and the two substances unite. The product, which is called *sulphuret of lime*, or liver of sulphur, has no smell, and is simply a compound of lime and sulphur. When it is exposed to the air, or moistened with water, the peculiarly fetid odor of sulphureted hydrogen is given off; part of the sulphur decomposes the water; the hydrogen of the latter dissolves a portion of the sulphur and produces an acid, which immediately unites with the lime, and thus the *hydro-sulphuret of lime* is formed.

The same compound is obtained by boiling sulphur in lime-water, or milk of lime; the liquid becomes brown and exhales the same odor. This compound of sulphur, when prepared in the dry way and afterwards moistened with water, undergoes decomposition by exposure to the air, the sulphur absorbing oxygen. When mixed with acids it is rapidly decomposed, and gives out an additional quantity of sulphureted hydrogen; very good artificial imitations of natural sulphureted baths may thus be made.

Lime and phosphorus may also be made to combine by being fused together. The resulting compound is a brown substance called *phosphuret of calcium*, which possesses even to a greater degree than the sulphuret the power of decomposing water. In this combination a great quantity of phosphureted hydrogen gas is disengaged, part of which escapes and takes fire upon coming in contact with the air, while the rest is retained by the lime, and cannot be disengaged except by the intervention of other acids.*

As far as present experience goes, it does not appear that lime combines with pure hydrogen, nitrogen, or carbon; but there is no doubt of its being able to unite with these substances when they are combined together, or of its capability of uniting with carbureted hydrogen and the compounds of carbon, nitrogen, and hydrogen. This fact shows us the reason that organized bodies are attacked and destroyed by quick-lime. When such bodies are placed in contact with the lime, they lose their cohesion and color, and are reduced to a friable mass. Carcasses covered with lime are rapidly decomposed without exhaling those noxious vapors

* The phosphuret of calcium decomposes the water, the hydrogen of which combines with the phosphorus, forming phosphureted hydrogen; while its oxygen combines partly with the calcium, forming lime, and partly with the phosphorus, forming phosphoric and hypo-phosphoric acids. These acids unite with the lime and form phosphate and hypo-phosphate of lime.

which accompany their putrefaction under other circumstances. It is on this account that quick-lime is placed in the coffin with the bodies of those individuals who have died of contagious diseases. Even living organized bodies, as tender plants and seeds, insects and their larvæ, are also attacked and rapidly destroyed by quick-lime.

These phenomena, which are produced by lime as well as by the alkalies, sufficiently prove that it has an affinity for the elements of which organized bodies are composed, viz., hydrogen, carbon, and nitrogen, as it is impossible to believe that a substance which acts with so much energy upon organic bodies, can be destitute of affinity for their elements; we are rather led to conclude that it tends to combine with some one or more of these elements, which are united in all organic bodies in certain definite proportions; and that by its combination it destroys the equilibrium of the whole mixture.*

Slaked lime does not produce these effects to the same extent as quick-lime, because its action is not assisted by that increase of temperature which accompanies the action of the latter; nevertheless, it has sufficient power to accelerate the decomposition of organic substances. On this decomposing power, the beneficial effect which it produces when used as manure in a great measure depends. It accelerates the decomposition and disintegration of the manure already contained in the soil, and causes those portions which are most advantageous to plants to be developed in the greatest quantity. For the same reason, it tends to accelerate the exhaustion of the soil; which, consequently, is rendered more sterile if it be not speedily ameliorated. It is this action which makes it so necessary, where lime is used for the purpose of improving the land, to manure it at the same time with a quantity of dung or some such matters. But it must also be allowed that carbonate of lime exerts a similar influence upon organic bodies, especially where putrefaction and decomposition have already commenced. The carbonate also appears to possess, although in an inferior degree, the power of acting upon certain combinations of hydrogen, nitrogen, and carbon, taking up a certain portion of them, and thus weakening or perhaps destroying their original state of combination.

One of the most remarkable properties of lime—a property which renders it so eminently useful as a building material—is, that it hardens when mixed with certain stony substances and made into a fluid paste, and forms with them a matter which possesses the firmness of rock. Mortar, made of sand and slaked lime, soon dries when exposed to the air. This composition not only possesses great cohesion in itself, but also adheres firmly to other stony substances, and serves to unite them together. This cohesive power arises from the strong affinity which exists between silica and lime. A mixture of lime and water presents numerous points of contact to sand, stones, and other kinds of hard substances which are chiefly composed of silica, and thus its cohesion with them is strengthened; the water evaporates, and by so doing still farther arguments the cohesion; finally, the lime absorbs carbonic acid from the air, and thus undergoes a sort of crystalization, which increases to a yet greater extent both its own cohesion and its adhesion to bodies of a silicious nature.

Lime cannot, even by the most intense heat, be made to fuse, unless it is mixed with other substances. Too great a degree of heat does, however, produce a certain change in its properties, rendering it insoluble in water and unfit for making mortar. This tendency is well known to those who have the management of lime-kilns, and they cautiously endeavor to guard against it. When it has undergone this alteration, it is called *dead* or *burnt lime*. This condition is that of a species of vitrification or agglomeration; the cohesion of the integral parts is augmented, and the affinity for water is greatly diminished by this change. But lime may be completely fused when mixed with silica.

Lime has a powerful affinity for acids, and for most of them its affinity is even greater than that of the alkalies properly so called. It attracts carbonic acid more powerfully than potassa, soda, or ammonia do, and can even deprive these

* When lime is mixed with tallow, and certain other organic substances, it forms a soap. Lime, and some of its salts, when mixed with common alkaline soap, decomposes it, and forms a soap of lime; which, being insoluble in water, forms a white curdy matter which swims upon the surface of the water. Waters which owe their hardness to the presence of either sulphate of lime, (gypsum) or carbonate of lime (chalk), always produce this effect upon soap.

substances of the carbonic acid which they may possess; it is, therefore, employed as the best means of converting the alkaline carbonates into caustic alkalies. It has, also, a greater affinity than the pure alkalies for the sulphuric, nitric, muriatic, and phosphoric acids; the alkalies, therefore, cannot decompose the compounds of lime with these acids.

When acids are brought in contact with calcined lime that has been previously slaked, the combination takes place promptly and without effervescence. If the acid used be the nitric or muriatic, both of which form soluble neutral salts with lime, the latter is dissolved by the liquid and ceases to be visible, the fluid becoming perfectly clear. But if the compound be a neutral salt which is insoluble, or, at all events, difficult of solution, as is the case when sulphuric or phosphoric acid is used, the lime remains suspended in the liquid, and separates anew after having entered into combination with the acid.

When liquid acids mixed with water are poured upon lime which has been calcined, but not slaked, a disengagement of heat takes place, which causes the liquid to effervesce. This effect is due less to the action of the acids than to the absorption or crystalization of the water, and is very different from the effervescence which accompanies the action of acids upon the carbonate of lime.

Carbonate of lime dissolves in acids quite as readily as calcined lime; while this solution is going on, carbonic acid escapes in the form of gas. This gas rises to the surface of the fluid in the form of bubbles, and causes a violent effervescence. As this phenomenon always accompanies the solution of carbonate of lime in an acid, it has been regarded as a certain indication of the presence of that substance in any earthy body. If effervescence takes place when an acid is poured upon the earth, the presence of lime may be inferred; but this evidence must not, however, be regarded as conclusive or unexceptionable. If an addition of acid causes no effervescence, it may then be reasonably believed that the earth does not contain carbonate of lime, at least in any appreciable quantity; but the contrary does not so necessarily follow, because the same phenomenon is produced by the disengagement of carbonic acid from the carbonate of magnesia or iron when acted upon by acids; the effervescence attributed to the carbonate of lime may, therefore, be caused by the presence of one of these substances.

When calcined lime combines with acids, it loses the causticity and alkaline properties, and the acids themselves also lose their distinguishing characteristics. The effect is the same whether it be the carbonate or calcined lime which combines with the acids. In either case the resulting compound is a simple combination of lime with the acid employed.

The neutral salts which lime forms by its combination with acids, exhibit different properties with the acids by which they were produced; they are, also, sensibly different from those which the same acids form with other earths. We shall not here attempt to enter into a minute examination of more than one of these salts, viz., the sulphate of lime, or gypsum.

Among the calcareous minerals essentially composed of carbonate of lime, we distinguish the following:

1. *Calcareous-spar.*—Is composed entirely of carbonate of lime; it is found in crystals or in masses in the interior of strata, and not unfrequently serves as a matrix for metallic ores. Its crystals vary between the forms of the prism, the pyramid, the rhomboid, &c. Calc-spar is more or less transparent, colorless, and breaks into rhomboidal fragments. The transparent rhomboidal crystals of calc-spar have the property of multiplying the objects seen through them.

2. *Limestone.* Whole mountain chains are found composed of this rock: it is extracted in order to be calcined and converted into lime, a purpose for which it is peculiarly adapted. It is hard, and usually of a greyish hue, inclining to red or yellow; occasionally it is found variously colored. The grey variety is the best. It is, moreover, distinguished by the form of its fracture; some kinds of limestone having an earthy, some a scaly, and others a schistous fracture. Limestone always exhibits a greater or less degree of hardness, but is never sufficiently hard to emit sparks on being struck with steel. It does not, naturally, possess either lustre or transparency, but sometimes acquires the former from polishing. Limestone often exhibits impressions and petrifications of testaceous animals; sometimes it is impregnated with bituminous substances, and, in that case, on its fragments being rubbed together, it emits a fetid odor similar to

that of garlic. This variety is called *stinking stone*, or *swine stone*, or *lapis suillus*.

Limestone is not generally so pure as calc-spar, and it often contains oxide of iron, alumina, and silica. According to Simon, one hundred parts of Rüdersdorff limestone contain—

Chalk	53·0 parts.	Iron	0·75 parts.
Carbonic Acid	42·50 "	Water	1·63 "
Silica	1.12 "		——
Alumina	1·0 "		100·0

According to the same author, Swedish limestone contains rather more silica, alumina, and oxide of iron, and likewise a little of the oxide of manganese.*

Marble is a species of concrete limestone, which is only distinguished from the others by the small admixture of foreign bodies which it contains, by being considerably harder and finer grained, and by the variety of its hues, which latter often give to it a very beautiful appearance.

3. *Chalk*. This is a species of concrete lime, of different degrees of hardness, meagre to the touch, slightly inclined to stain or soil whatever it comes in contact with, and capable of being easily reduced to powder. It is of a white or yellowish white color, and derives its name from the Isle of Crete or Candia, in which large quantities of very fine chalk are found. It may also be procured from other countries, in some of which there are large hills composed entirely of it—as, for example, in England, Denmark, France, &c. Chalk may be employed in the manufacture of lime, and is also in daily use for various other purposes.—There are other fossils which are often called by the same name, but which, nevertheless, must not be confounded with this substance. Spanish chalk is a species of stealite, which belongs to the class of magnesias. Black chalk is of the schistous species.

4. *Pulverulent lime*. In hills, plains, and low grounds, a species of friable white earth is often found, bordering in hue, more or less, on yellow or grey, and which is principally composed of carbonate of lime. It is meagre to the touch, possesses a small degree of consistency, and, when impregnated with water, does not form a concrete mass. We call it pulverulent or earthy lime, but in many places it is known as *marly lime*, and is sometimes denominated *marl*. It consists of too great a proportion of lime, containing at least ninety parts of it in a hundred, to admit of its being classed among marls. It is moulded into the form of tiles, in order to be reduced to quick lime by calcination, but it may be advantageously employed as a manure without being submitted to the action of fire—and the more so, as the simple action of the atmosphere is sufficient to reduce it to powder. It is, therefore, of great importance to the agriculturist, as, in all probability, its origin is the same as that of the kind we are now about to mention.

* The common varieties of lime, used by the English farmers, are procured by calcining either chalk or limestone. Such lime is, therefore, rarely, if ever, chemically pure, for it almost always contains a portion of silica (flint), alumina (clay), and some red oxide of iron. These, however, are not often present in sufficient quantities to influence the fertilizing powers of the lime to any material extent, as will readily be seen by the analysis of the limestones, and the chalk usually employed by the lime burners.

Carbonate of lime	95·05 parts.
Water	1·63 "
Silica	1·12 "
Alumina	1·00 "
Oxide of Iron	0·75 "

100 parts of common chalk contain—

Lime	56·5 parts.
Carbonic Acid	43·0 "
Water	0·5 "

united with various small proportions of the other earths. There is also a very considerable proportion of lime made in the north of England, from the magnesian limestones, called by the Yorkshire farmers "hot lime," all of which differ considerably in composition; that from Sunderland containing in 100 parts—

Carbonate of Lime	56.8 parts.	Clay, Water, &c.	2·00 parts.
Carbonate of Magnesia	40·84 "	Oxide of Iron	0·36 "

This "hot lime," which is well known by the farmers in the neighborhood of Doncaster, and other parts of the north of England, can only be applied in limited quantities, for the calcined magnesia of the limestone remains for a considerable period in its pure caustic form, without absorbing carbonic acid gas from the atmosphere, and in this state its effect is very pernicious to many kinds of plants. It is only when pure, however, that magnesia is prujudicial to vegetation; by exposure to the atmosphere, it gradually and slowly absorbs carbonic acid gas, becomes carbonate of magnesia, and in this state forms a part of many cultivated plants. Some of the most fertile soils of our island, in fact, contain it in this form, in considerable quantities.

The action of the fire upon the chalk and the limestones merely deprives them of their water and carbonic acid gas, or fixed air. The farmer must not fall into the very common error of supposing that anything is *added* by the fire to the lime; on the contrary, it loses very materially in weight, by being deprived of its carbonic acid gas, a loss, however, which it gradually recovers by exposure to the atmosphere, which always contains this elastic vapor. [*Johnson's Farmers' Encyclo.*

5. *Lamellated* or *shell lime.* This variety is sometimes found in mountains, but more frequently in plains, covered by a thick layer of black marshy earth.—On the surface there is usually a layer of shells, which, as we penetrate deeper, exfoliate into flakes; underneath these is a layer of loose friable lime; and, farther down still, a species of lime almost as hard as a stone. It is here easily perceptible that this substance has been formed from the remnants of testaceous animals, and that it has gradually become hardened into stone.

6. *Stalactites* and *calcareous crystalized concretions.* These varieties have been produced by the droppings of water, which has dissolved a great deal of carbonate of lime by means of the carbonic acid which they contain. In proportion as this acid has become evaporated, the lime has been deposited and hardened on itself, or on any other bodies which it met with in its descent. Stalactites of various remarkable forms are frequently found, principally in grottoes, and especially in those called Bauman's or Biell's Höhle, in the Hartz mountains, in the Grotto of Antiparos, &c.

The calcareous sandy-stone is a concretion which is formed by the depositions of water. It is found at Carlsbad in Silesia, among the Hartz mountains, and in almost all places where there are calcareous mountains. Sometimes it assumes the form of little balls, adhering to one another, which are either hollow or contain a kernel of sand. They are called *stones of peas*, or *fossil lentil.*

Gypsum, or Sulphate of Lime.

Of all the various concretions which are formed by combinations of lime with different acids, we shall only enter into an examination of one, namely, that which results from the union of lime with sulphuric acid, and is commonly called gypsum, but which is known to scientific men by the name of sulphate of lime. This body is perfectly insipid, and can with difficulty be dissolved in water; when it has been purified, either by some combustible matter or metallic oxide, it is always of a whitish color. According to Buckholtz, it takes 461½ parts of water to dissolve one part of gypsum, but the data with regard to this point vary considerably. Buckholtz also states that the dissolving powers of warm and cold water on this substance are almost equal; but other authors assert that warm water dissolves the greatest quantity of it. The difficulty in dissolving gypsum is the reason that it can never be produced in the form of crystals. The solution of it only produces a few crystaline grains. It is also on this account that large quantities of lime, dissolved in sulphuric acid, cannot be obtained in a liquid form, and that it always remains behind in the filter. If sulphuric acid, diluted with water, is poured upon lime, a combination certainly takes place; but the gypsum which results from it presents itself in the form of a white indissoluble powder, only a very minute portion being held in solution by the fluid.

The solution which contains this small portion of gypsum exactly resembles pure water; it has, however, a slight taste, although the powder itself is absolutely insipid. This taste is not easily described; it is remarked in most water that contains a solution of gypsum, and it is then called *hard* water. If this solution be gradually evaporated, gypsum will continue to be precipitated during the whole of the process, for the remaining fluid will only retain that quantity which it can hold in solution. Water containing carbonic acid dissolves a much greater portion of gypsum than pure water; but, in proportion as the acid evaporates, the substance held in solution will be precipitated: thus, if the fluid be exposed to the influence of the atmosphere, it loses the chief part of its gypsum; and, if it be boiled, the whole of the substance will be found deposited at the bottom of the vessel. Waters impregnated with gypsum, or, in other words, *hard waters*, are totally unfit for many purposes; but when applied to the irrigation of meadows, the effects are ameliorating and fertilizing.

According to the experiments made by Buckholtz, gypsum is composed of thirty-three parts in a hundred of lime, forty-three of sulphuric acid, and twenty-four of water of crystalization. There may, however, exist varieties of this substance which contain different proportions.

When exposed to the atmosphere, gypsum does not lose its water of crystalization; but, if submitted to the action of fire, the water is immediately evaporated, without, however, the gypsum being cracked or broken. It loses in weight all the water which it previously contained. In order to produce this effect, it is

not necessary that any very great degree of heat should be applied; it may even be inferior to that which is requisite to effect the calcination of lime. When gypsum which has been broken into moderate-sized pieces is passed through the fire, it becomes calcined, and is at the same time rendered perfectly soft, so much so that it can be easily crushed between the fingers.

Gypsum which has thus been deprived of its water of crystalization by the action of fire, is termed calcined gypsum or plaster. When in this state, it may be used as mortar, or formed into moulds or casts. When the plaster is reduced to a very fine powder, and mixed with water, it rapidly absorbs that fluid, and solidifies and combines with it, the same as with the water of crystalization. In this change a disengagement of heat takes place, similar to that which results from the combination of lime and water; but the elevation of temperature is not so sensible in this instance, because the union does not take place so promptly. If more water is added than the plaster requires for the purpose of crystalization, the mixture remains for some moments in the form of a thick paste, but eventually unites into crystals, and forms a compact mass. It is this property which renders it so useful as a stucco.

Calcined gypsum, when exposed to the atmosphere, gradually absorbs moisture, which it combines with in the form of water of crystalization, and thus increases in weight, but at the same time loses its faculty of effervescing when mixed with mortar, and also its utility as mortar. When this is the case, it can only be restored to its pristine state by being calcined afresh; when this has been done, it is once more available for mortar.

If, during the process of calcination, gypsum should be exposed to too great a degree of heat, it undergoes an alteration similar to that which lime experiences in like circumstances. When burned, it no longer effervesces when brought into contact with water, loses its beneficial effects as a manure, and cannot be made into stucco.

Gypsum can only be fused by means of a very intense and prolonged degree of heat. When it has undergone this process, it not unfrequently evolves light when placed in a dark place. The heat does not effect the decomposition and separation of the sulphuric acid from the lime; it only deprives the gypsum of its water. This substance is only decomposed when, along with coal or vegetable bodies, it is absolutely ignited; then only does its sulphuric acid become deprived of oxygen; and a portion of the sulphur thus separated is evaporated, while the rest remains combined with the lime, thus forming sulphuret of lime or liver of sulphur. This will account for the sulphurous smell which always prevails in the neighborhood of gypsum kilns.

It is probable that a similar combination is effected, though much more slowly, at a less elevated temperature, when the gypsum is united with bodies impregnated with carbon, and which are in a state of putrefaction; a portion of the beneficial effect of gypsum in ameliorating land arises from this circumstance.—When water impregnated with gypsum is foul or muddy, it gives out a fetid sulphurous odor. Fourcroy attributes the bad smells which prevail in some towns in the neighborhood of Paris to this quality.

Lime has a greater affinity for sulphuric acid than the alkalies have, and, consequently, gypsum cannot be decomposed by these substances; but alkaline carbonates easily effect a complete decomposition of it by means of a double combination. If, for example, powdered gypsum is boiled in a solution of carbonate of potassa, this latter combines with the sulphuric acid, while the lime unites with the carbonic acid. The lime then passes in the form of a white powder into the state of carbonate of lime, while the alkaline sulphate is dissolved in the fluid.

The gypsum which is met with in the mineral kingdom sometimes constitutes entire mountains. It is found under various forms—sometimes as a pulverulent body, at other times in large masses, and occasionally crystalized. The following are some of the kinds most frequently met with:

1. *Powdered gypsum, celestial farina.* This gypsum is pulverulent; it is found in the neighborhood of gypseous rocks, from which it has been separated and reduced to powder by the action of water. In some places it is seen issuing from the earth. At a period of scarcity and famine, this substance was supposed to be meal or flour sent down from heaven; it was gathered up, mixed with real flour, and made into bread, which, as might have been expected, was not calcu-

lated for the sustenance of mankind, but which, nevertheless, was not so immediately injurious as many persons may be disposed to believe.

2. *Common compact gypsum.* This variety is found in large masses in secondary mountains. It is not very hard, breaks with a crackling sound when crushed between the teeth, cannot be polished, and is so tenacious that it is scarcely possible to reduce it to powder. It is met with of different colors, but is generally either grey or white. Alabaster belongs to this species, and bears the same relation to gypsum that marble does to lime; it is a semi-crystalized stone, capable of receiving a high degree of polish, and is used for various kinds of sculpture, vases, statues, &c. Sometimes it is beautifully variegated with all kinds of colors, which are produced by metallic oxides. Alabaster is not capable of so high a polish as marble, because it is not so hard or compact, and is apt to become deteriorated by exposure to the air.

3. *Gypseous spar*, or *crystalized gypsum.* This variety is frequently found in places where there are considerable quantities of gypseous stone or compact gypsum, and is closely combined with it. It is more or less transparent, variously shaded, and may be split with a knife into thin, soft, and transparent flakes.

The kind called *glacies mariæ* also belongs to this variety, which is found in large rhomboidal crystals, and can easily be cut. Sometimes the gypseous spar is met with in large crystals, bearing the form of tables or pyramids. This substance is likewise very tenacious, and can with difficulty be powdered.

4. *Gypseous stalactites* have originated in the same manner as the calcareous stalactites; that is to say, they have been formed by the depositions of carbonated waters which held a considerable quantity of gypsum in solution. Sometimes gypsum and carbonate of lime are found mixed together. These calcareous gypsums effervesce when brought in contact with acids.

There are many waters which hold gypsum in solution. This is frequently the case with spring water, which is then called hard or rough, and is unfit for various purposes, and especially for the distillation of brandy. Gypsum is occasionally met with on the surface of the soil in combination with lime or clay; it is likewise found in the ashes of certain vegetables; but, in all probability, it does not exist in plants, but has been produced, during the combustion, by the combination of the sulphuric acid with lime.

MARL.

This substance, which is of so much importance in Agriculture, has long been known to many farmers as an active agent in ameliorating and increasing the fertility of land. In many countries there are whole districts which have formerly been improved by the use of marl. Its properties in this respect were known and recognized by the Romans; but it is only lately that the marling of land has attracted general attention, and there are still many agriculturists who have not a distinct idea of this substance, although a small amount of chemical knowledge is requisite to enable them to distinguish it from other earths. It is this total ignorance of the nature of marl which frequently causes them not only to deny its beneficial properties, but even to decry it; and hence it is that they pretend to have seen such evil consequences to result from the use of it. There is no doubt that the substance which they applied to their land as marl was some more tenacious and ferruginous clay, or some other kind of earth which did not agree with the soil. We shall hereafter speak of marl as a manure; at present we have only to explain its nature and the manner in which it generally exists in the soil.

Marl is a combination of carbonate of lime and clay. These two bodies are usually found in so complete a state of amalgamation that it is impossible to distinguish the particles of one from those of the other, either with the naked eye or with the aid of a microscope. The agents by means of which this union is effected have not, as yet, been discovered; for, when clay and lime are mixed together artificially, the substance formed is very different from natural marl—for example, it does not possess the faculty of losing its aggregation, when exposed to the influence of the atmosphere, and crumbling to dust like natural marl.

The proportions in which clay and lime are found combined in marl are many and various. Sometimes there are equal quantities of each of these substances, while in others the one predominates considerably over the other. Nature does not seem to have prescribed to herself any rule for the regulation of the propor-

tions in which they shall be united. Marl has been classed under different heads, according to the proportions of lime or clay of which it is composed. The classification adhered to by *Andrea*, in his work on the various species of earth in Hanover, is decidedly the best, and is the one generally adopted throughout the greater part of Germany. According to this author, marl is simply a combination of nearly equal parts of clay and lime. If the former predominates so much as to constitute nearly or quite two-thirds, the mixture is then called *argillaceous marl;* and if the proportions of clay are still greater, so that there are three parts of that substance to one of lime, it is then called *calcareous* or *marly clay.* On the other hand, if the lime predominates and forms nearly or quite two-thirds of the mixture, it receives the name of *calcareous marl;* and when the quantity of this substance is still farther increased, so that it constitutes three parts while there is but one part clay, then the combination is termed *argillaceous lime.*

Marl, in all its varieties, is met with in a great number of countries. Indeed, there is no doubt that, if carefully sought, it will be found in most places; it has been proved that almost all the inferior strata of the soil contain some portion of it. There are very few countries in which it does not exist, or in which it is too deeply imbedded in the earth to be extracted with any degree of profit. It is nowhere met with in such abundance as in hilly or mountainous countries, in the neighborhood of stratiform or secondary mountains, of which it constitutes the principal part of the inferior layers of the soil, and is disposed in continuous banks. It is not so easily found in dry, flat, or marshy countries; and it is there deposited in heaps, at unequal distances and at various depths. The existence of a stratum of marl beneath the soil may generally be inferred when certain plants are found upon the surface, viz. *tussilago* or *coltsfoot* (*tussilago farfara*), *tussilago alpina*, *yellow flowered sage* (*salvio glutinosa*), *meadow sage* (*salvia pratensis*)—all which flourish much better in marly than in any other soils. It is not the presence of the plants alone which may be regarded as indicative of the existence of marl; wherever they are observed to multiply and flourish with peculiar richness of vegetation, they will generally serve as guides to the discovery of marl.

The presence of *black medic* or *nonsuch* (*medicago lupulina*), on a soil which has not been manured, may, in my opinion, be considered as an indication of marl. This substance, or, at any rate, marly clay, may generally be found under briars. When marl exists in heaps, at a certain depth below the surface, it frequently shows itself at the edges of ravines, or in uneven roads, from which the layer of earth which covered it has fallen or has been rubbed off. These heaps of marl are frequently again covered by clay; wherever this latter body is found intermingled with grains of lime, there is every probability that marl will be met with if we penetrate sufficiently deep into the soil. The beds of marl are not by any means equal in thickness throughout their whole extent; this observation applies particularly to argillaceous marl. There is generally less of lime in the superior than in the inferior strata; and, usually, the lower we descend the more calcareous does the bed become.

Both clay and lime contribute to constitute the properties of marl; in this mixture these two kinds of earth form a mutual exchange of their reciprocal qualities. The tenacity and unctuous quality of the clay is tempered by the lime—while, on the other hand, the harshness or stiffness of the lime is softened by the admixture of the clay. According as one or the other of these substances predominate, so do the characteristics of it predominate in the marl.

Marl, properly so called, is composed of equal parts of clay and lime, and cannot be assimilated to either the one or the other of these substances; the properties of both are amalgamated in equal proportions. Argillaceous marl or calcareous clay approaches more to the qualities of clay; therefore, when impregnated with water, it becomes unctuous, more ductile, emits a clayey odor, and, in drying, reünites into hard clods, which are, however, malleable. Marly clay, when moistened, is frequently more difficult to work than clay deprived of marl; but it is much more easily dried. Calcareous marl and argillaceous lime assimilate more to lime, when dry; they are less rough to the touch when moist; they have less cohesion; and, when the fragments are dried, they can easily be crushed between the fingers. It depends a great deal upon the nature of the clay which enters into the composition of these marls, whether they are rich or poor. A rich

clay requires the addition of a larger quantity of lime, in order to correct its defects; while in a poor clay a much smaller proportion will produce the same effect. Two varieties of marl are often met with—one of which, in its external appearance, greatly resembles argillaceous marl, and the other is like calcareous marl—and yet both of these contain equal quantities of lime; but the former is composed of rich tenacious clay, while the latter, on the contrary, consists of clay of a poorer quality. The nature of the latter substance has also a considerable influence upon the qualities of the marl.

Marl is of different colors—being sometimes white, yellow, brown, grey, violet, red, blue, or black. These colors are produced partly by the oxides of iron or manganese which it contains, and partly by combustible matters, as bitumens or humus. Those varieties of marl which contain only the latter are usually grey, bluish, or black, and combustion renders them white. Those which are impregnated with bitumen give out the color peculiar to that substance when heated, or when pieces of it are rubbed together. The color of the marl is a very uncertain indication; at most, it can only enable us to appreciate the quantity of combustible matter or metallic oxide which it contains; it will not serve to distinguish the nature of the marl, or the proportions of clay and lime which compose it. Marls of the same color frequently differ essentially in the proportion of their elements; while others, which in external appearance are perfectly dissimilar, show no differences in point of composition.

With respect to the consistence and contexture of their parts, the marls differ essentially among themselves. Sometimes they are soft to the touch as dust, or possess so slight a degree of consistency that they may easily be crumbled to pieces between the fingers; while others are hard as a stone. The former are called "earthy," and the latter "concrete" marls. This latter species is still farther distinguished by its contexture: it either has a schistous fracture, and is composed of flakes laid over each other, which can be separated with a knife; or it has no uniform layers, but, when broken, flies into irregular pieces. The former of these is called "schistous," and the latter "stone" marl. No decisive conclusions with respect to the nature and composition of marl can be deduced from these differences of conformation. Sometimes concrete marl contains a superabundance of marl, and at others a superabundance of lime; and, when this is the case, it bears a greater resemblance to limestone. If we find a marl belonging to the species which we call calcareous, we must not, on that account, infer that it contains a superabundance of lime; for it is possible that the clay was naturally poor, so that the marl had not a great deal of consistence. When water is poured upon marl, that fluid penetrates, with greater or less facility, into all the pores, destroys the cohesion of the parts, separates them from one another, and reduces them to a fine powder. This is one of the essential properties which serves as the first distinction of marl, and by means of which this substance ameliorates the soil, by mingling completely with its surface. The air shows itself in bubbles which rise in the water, sometimes making a slight noise and occasioning a kind of effervescence. It certainly cannot be admitted as a principle that any kind of earth which loses its aggregation in water must necessarily be marl, since very poor clays are affected in the same manner; but if any kind of earth is not spontaneously reduced to powder by the action of water, we may feel convinced that it is not marl. Every kind of marl, even that which is called "stony," becomes soft and pulverized in water. This substance likewise loses its cohesive attraction when exposed to the humidity of the atmosphere, and is reduced to powder in the same manner as by the action of water, only the process occupies more time. It is this property which renders marl so useful as a manure. It is not at all necessary to pulverize it before it is put into the soil which is to be ameliorated—that operation may be left entirely to the influence of the air; the humidity of the atmosphere penetrates into the marl deposited in the soil, and reduces it to powder. Frost contributes materially towards effecting a total division of the particles; and, indeed, with concrete and tenacious marls, its assistance is often absolutely necessary; and this is the reason that these marls are generally laid on before the approach of winter. The moisture which the marl has absorbed is expanded by the frost, and forces the parts asunder.

The time which is required to reduce marl spontaneously to powder by the

action either of air or water, depends in a great measure upon the proportion of clay which this substance contains in its composition, and upon the degree of hardness and of the cohesion which exists between its parts. Pure compact limestone will not resolve into powder, neither will pure solid clay. If, therefore, lime forms the predominating ingredient in marl, this latter does not lose its aggregation; the same effect is evident where clay forms the chief constituent part, or, at any rate, the division is effected very slowly. In order that the cessation of cohesion may be promptly brought about, it is evidently necessary that there should be a certain proportion of these two substances, and the degree of this proportion will depend entirely upon the nature and the richness or poverty of the clay.

In marls composed of similar clays, but which contain proportionately different quantities of lime, the substance which, properly speaking, ought to be called marl is that which is most easily deprived of its cohesive qualities; and, on the other hand, calcareous and argillaceous marls are those which oppose the greatest resistance to the action of fire, water, and air. The division is never so slowly effected as when the parts have acquired the hardness of a stone, as in the case of stony marls; while among the number of concrete marls, those which are of a schistous nature lose their aggregation much sooner than those which are found in homogeneous masses.

Marl produces a very great effervescence when brought into contact with acids or acidulated fluids. If the latter are poured upon this substance, they combine with the lime; while the alumina remains untouched, so long as the acids have any lime left to dissolve; it is only when all the lime has been absorbed and the acid still remains unsaturated, that it attacks and dissolves a small portion of the alumina and of the oxide of iron.

It is well known that carbonate of lime cannot be fused without the agency of some other substances, and that clay is scarcely vitrified even by the hottest fire; but that if these two earths are united, they may then be melted without difficulty; marl, therefore, is a substance capable of being fused and vitrified. It does not require any great degree of heat to melt it, and this is the reason of its being used for the purpose of separating metals and facilitating the fusion of metallic gangues.* It is sometimes used to procure iron.

Marl is occasionally found intermingled with other substances, which do not, properly speaking, belong to its composition. Of these, magnesia, sand, and gypsum are most frequently met with. Magnesia is often found in marl, and especially in that kind the beneficial effects of which as a manure are most evident. It also exists there in a state of carbonate, effervescing when brought in contact with acids, and dissolving in them. These circumstances have caused magnesia to be frequently confounded with lime when the marl is only superficially examined. But as we are as yet ignorant of the effect which it produces, it is very important that it should be properly distinguished and inquired into. Marl which contains magnesia is called "magnesian marl," and it is still farther distinguished by the terms "argillaceous" or "calcareous magnesian marl," according as the clay or lime predominates. This substance always contains a small portion of sand; when the quantity is considerable, the marl which contains it is called argillaceous or calcareous sandy marl. If the proportion of sand amounts to sixty, seventy, or eighty parts out of a hundred, then the substance is called "sandy marl." A slight admixture of sand in marl is highly beneficial to that substance, causing it more rapidly to part with its aggregation. Marl likewise contains some portion of gypsum, which occasionally shows itself in small crystaline veins, and is rendered still more susceptible when the marl is heated; the presence of gypsum probably ameliorates the marl, and renders it more friable; but we have not, as yet, any certain information on this point. If the marl contains considerable quantities of gypsum, it is then called argillaceous, or calcareous gypseous marl.

The external appearances under which marl is found are many and various. The following are some of the principal varieties, not classed according to their internal composition, but according to their external appearance:

(*a*). *Stony*, and frequently *schistous marl.* This kind is, in most cases, toler-

* "Gangue," a German word, signifying the rock to which the metal or mineral is attached in the bowels of the earth.

ably friable while in the earth; it is only when exposed to the atmosphere that it hardens and changes color, and then the lapse of two or three years is barely sufficient to deprive it of its aggregation. This marl is often very calcareous, and so much resembles limestone that it is sometimes calcined in order to be made into lime, or used in its rough state as marl. But the lime produced from this substance is impure and bad in quality. This marl occasionally has the hardness and all the other appearances of common lime; however, the proportion of alumina and silica contained in it is usually greater than in lime.

(*b*). *Argillaceous* or *clayey marl*. We have already mentioned the distinguishing characteristics of this variety.

(*c*). *Lamellated marl*. This kind is only found in thin layers.

(*d*). *Shell-marl*, on the surface of which the remains of marine and land shells are frequently found. Farther down it resembles dirty chalk, and lower still it is sometimes crystalized and stony. This marl is hardly ever found except in plains, under turf, peat, black or marshy earth, and in places where water has formerly been stagnated. It is principally composed of lime; and has, therefore, been called marly lime, and is frequently calcined and used as lime. It is separated by the action both of air and water; and when mixed with a suitable proportion of that fluid, although without being calcined, it is used for bleaching. When applied to land, this marl does not act so promptly as might have been expected; it often contains phosphoric acid.

The first variety (*a*) is hardly ever found excepting in mountainous countries; the second (*b*) is generally met with in hills covered with brown clay, in which briars have taken root. Sometimes these hills are anything but fertile, even when the clay which is on the surface contains calcareous particles. The marl appears to have rapidly consumed the humus, or perhaps this latter substance having been rendered more soluble by the marl, has been carried away by heavy rains. But the fertility of these places will soon be restored if they are abundantly manured. I state this fact in order that agriculturists may not be prevented, by the apparent sterility of the land, from digging it up in order to discover the marl. The last two varieties (*c* and *d*) are only found in flat grounds and plains.

MAGNESIA.

This earth is less diffused throughout nature than either of the preceding. It is never met with pure, but always mixed with other earths and combined with acids. Several minerals contain portions of it; springs, rivers, the sea, and salt water also contain it, but it is then principally combined with the muriatic and sulphuric acids. It also enters into the construction of animal bodies, and is then generally united with phosphoric acid. The ashes of most vegetables contain more or less of it; it sometimes forms a very considerable constituent part of the layer of vegetable mould, and of that marl which is best adapted for the purpose of manure. This earth, which has not long been discovered and distinguished, has latterly awakened great attention as regards its relation to Agriculture. Bergmann and other authors have represented it as very fertile; but Tennant, an English chemist, observes that some calcined lime which had been used to ameliorate land had produced quite a contrary effect; and on being analyzed, it was found to contain a great deal of magnesia; and thence he arrives at the conclusion that the effects of this earth are always prejudicial. In its natural state it rather resembles carbonate of lime in all its points. Lampadiers found it to be very favorable to the vegetation of barley; and Einhoff, when analyzing a peculiarly ameliorating marl, found it to contain twenty parts in a hundred of magnesia.

Carbonate of magnesia is both insipid and inodorous. When moistened and mixed with water, it forms a consistent matter which soon dries up. With regard to its disposition to retain water, it may be assimilated to carbonate of lime, and, indeed its relations to water are generally the same as those of that substance. Carbonate of magnesia is insoluble in pure water; it can only be dissolved in water which has been impregnated with carbonic acid gas.

Pure magnesia, freed from carbonic acid, is easily distinguishable from lime. It is neither caustic nor alkaline like that substance; it does not emit any heat when mingled with water; the paste which results from this mixture does not harden in drying; and when sand is combined with it, a mortar is not produced.

In fact, it appears to absorb water and appropriate it, but without depriving it of its fluidity. It effects a very slight alteration in blue vegetable colors.

The following are the fossils which contain magnesia, and which are greasy and soapy to the touch:

1. The *serpentine-stone*. This is a hard, fine-grained stone of a dark green or grey hue, occasionally striped or spotted with red. It is found in beds which sometimes constitute entire mountains. The best quarry of this kind of stone in Germany, is at Topplitz, in Saxony, where an almost incredible quantity of it is worked. It is manufactured into snuff-boxes, fancy boxes, vases, candlesticks, mortars, and all kinds of cups and vessels by means of turning machines; and afterwards polished with fine free-stone. The constituent parts of this substance are magnesia, silica, and oxide of iron.

2. *Talc*. This substance has a lamellated fracture: it is very greasy to the touch, and is sometimes found in the form of earth; at others, under that of stone. The former is composed of unctuous and slightly luminous parts, and is in general nearly or quite white; the latter, on the contrary, is harder, and may be divided into thin flakes, which frequently have the brilliancy of gold or silver, on which account it has been called *argentium*. It is used for the purpose of diminishing friction in machinery, and is one of the best agents which can be employed, being far preferable for that purpose to either soap or oil, because it does not occasion any dilatation of the wood, and it also preserves the metal from the almost insensible effect occasioned by friction.

Talc is composed of forty-four parts in a hundred of magnesia, and fifty-six of silica and alumina.

3. *Lapis ollaris*, or *soap-stone*, is a variety of talc; it is greyish, grey, or deep green, and may be turned and made into all kinds of vases, &c. It is principally found in Switzerland.

4. *Soap-rock*, or *earth*, is a species of opaque smooth stone, as unctuous as soap, which may be scraped off with the finger nail, and stains or soils every object with which it comes in contact. There are several varieties of it, some of which are soft, and others compact; the latter is also called Spanish chalk, because it was originally brought from that country. By means of it, figures or words may be drawn upon glass; and, although all traces of the writing vanish when the glass is washed, they reäppear as soon as it is exposed to a moist temperature. It is also used for drawing designs for embroidery, and is found in several parts of Germany, and particularly in Bareuth.

5. *Amiantus*, or *asbestos*. This kind of stone is composed of a filaceous tissue, the filaments of which are either arranged in parallel lines or transversely: in the former case, these threads are flexible, and it is then called "amiantus." It is generally of a whitish hue, bordering upon green, or a greyish green. Several other species are likewise found, which are called "*salamander's hair*," "leather fossil," &c., on account of some resemblance or fancied resemblance which they bear to the substances from which they derive their names. This stone prevails in Saxony, Silesia, Bohemia, Hungary, and Sweden. Those manufactures of incombustible linen, paper, and wicks for candles, which at one time appeared so incomprehensible, are formed of amiantus. In order to make linen, the thin flexible threads of the amiantus are spun with flax; it is then woven, and the cloth passed through the fire. When paper is to be made, the filaments are pounded and bruised until they are reduced to a pulp; all the usual processes attendant on paper-making are then gone through.

6. *Alcyonium*, or *froth of the sea*. The bowls or heads of those pipes which are so much prized are made of this substance. There formerly used to be some doubt with regard to its origin: it was thought to be a marine production; and hence derives its name; but it is known now to every person to be obtained from the village of Klitschik, not far from Conia or Iconium, in Natolia. It is found in veins in the cavities of a grey calcareous schist, a little below the surface of the soil. When first extracted, it resembles a soft paste, which, however, soon hardens when exposed to the air; it is made into the heads or bowls of pipes, and sold at Constantinople, where these are colored, or baked in oil or wax, and then exported to Germany, where they are worked afresh: pipes of a second-rate quality are made from the fragments of those which are broken. Notwithstanding its softness, this substance possesses a great deal of consistency, and is less

liable than most of the other fossils to snap to pieces. According to Wiegleb it is composed of equal parts of magnesia and silica: he asserts that it may be found in Spain, not far from Madrid; in Hungary; and in North America.

IRON.

We have already stated when speaking of clay that the soil frequently contains iron, which presents itself under various forms. We meet with it as an oxide totally free from acids, and under various degrees of oxidation, of a white, green, black, or red hue, and intimately combined with alumina; in this state it imparts all those different shades of color to clay which that substance is frequently found to possess. We do not as yet know exactly what influence it has upon vegetation, or whether or not it tends to ameliorate the soil. In many kinds of clay, we find oxides of iron in a state of carbonization: when in this state, it does not appear to have any influence at all on vegetation; and, at all events, it is not prejudicial to it. If stronger acids are then poured upon it, the carbonic acid is disengaged and effervescence takes place; therefore, this effervescence, which is regarded by so many persons as a certain sign of the presence of lime or marl, is a very deceptive indication.

We also find iron combined in the soil with sulphuric or phosphoric acid, but not very frequently. When in combination with the former, it produces that substance which is commonly called vitriol (sulphate of iron); land containing this compound is often called vitriolic earth. This matter is only found in those places where there are sulphurous pyrites, the composition of which produces the acid which combines with the iron. It may occasionally be met with in clay situated in damp places, but occurs most frequently in peat marshes, from which vitriol may sometimes be extracted with advantage. Wherever large quantities of vitriol are found, it is prejudicial to vegetation, and destroys the plants; while, on the other hand, when the soil contains only a small portion, and particularly when that is combined with bodies which contain carbon, as with coal or stone, it possesses a fertilizing property: this has been well attested by ancient as well as modern experiments and experience.

Iron is generally found combined with phosphoric acid in that substance which is called *marshy iron*. This body becomes diluted, and often mingles with the superior layer of the soil; where, being exposed to the action of the air, it gradually loses all those properties which are prejudicial to vegetation. Land in which the layer of vegetable earth rests upon marsh iron, is always of the very worst quality, and very sterile.

We must also mention oxide of manganese, which frequently enters, although but in a slight degree, into the composition of the superior layer of the soil, and which is generally found in plants and animals. We have not as yet succeeded in discovering whether or not it has any influence on vegetation.

We have now briefly mentioned the nature of those fixed and incombustible earths, or portions of the soil, which, by means of the proportions in which they are united, constitute all those innumerable varieties of land to which we shall have to recur when we have examined another constituent part of every soil adapted for vegetation, to which it owes its fertility, and which, properly speaking, is neither more nor less than that portion of the food of plants which they derive from the soil: we allude to the *humus*.

HUMUS.

The name usually given to this substance is "mould." This term has been misinterpreted by many persons, who have understood it to mean the layer of vegetable earth, and not a particular portion of its constituent parts. Several very clever agricultural writers have fallen into the same error; and thus the obscurity which enveloped this part of the science has been increased. It is on this account that I have adopted the word *humus*, about which there can be no mistake. In a scientific point of view the term "earth" is not at all applicable to this substance; properly speaking it is not an earth, and has only been called so on account of the pulverulent form.

Humus is always more or less a constituent part of the soil. The fertility of the land depends entirely upon its presence, for, if we except water, it is to this substance alone in the soil that plants owe their nutriment. It is the residue of

animal and vegetable putrefaction, and is a black body; when dry it is pulverulent, and when wet has a soft greasy feel. It is varied in its qualities and composition according to the substances from which it has been formed, and the circumstances under which the putrefaction or decomposition took place; there are, however, certain properties which are inherent to it, and in general it is similar in itself. It is the produce of organic power—a compound of carbon, hydrogen, nitrogen, and oxygen, such as cannot be chemically composed; for in inert bodies these substances only enter into simple combinations of some two amongst them, and do not unite altogether as is the case here. Besides the four essential elements of humus, it contains other substances in smaller quantities, viz., phosphoric and sulphuric acids combined with some base; and also earths, and sometimes different salts.

Humus is the product of living matter, and the source of it. It affords food to organization; without it nothing material could have life, at least the most perfect animals and plants could not exist; and, therefore, death and destruction are necessary and accessory to the reproduction of animal and vegetable life. The greater the number of living creatures, the more humus is produced, and, consequently, the supply of the elements for the nutrition of life is increased. Every organic being in life appropriates to itself a daily increasing amount of the raw materials of nature; and these, after having been digested, resolve into humus, which increases in proportion as men, animals, and vegetables are multiplied in any spot on the surface of the earth. It is, however, diminished by the processes of vegetation, wasted by being carried into the ocean by water, and by being conveyed into the atmosphere by the agency of the oxygen contained in the air, which unites with and gradually converts it into a gaseous matter.

We have only to observe the progress of vegetation upon naked rocks in order to understand the history of humus from the very beginning of the world. At first, only lichens and mosses are found there, from the decomposition of which more perfect plants derive their nourishment; these, in their turn, die and augment the mass of mould by their putrefaction: and thus at last a bed of humus is formed, capable of affording nourishment to the largest trees.*

Voigt, in his supplement to the researches of Saussure, justly observes, "that vegetable mould is vegetable matters partly decomposed, but not completely disorganized. It is a vast pervading plant without organization, which itself bears and nourishes other plants, as a tree affords nutrition to all its branches and shoots. This vegetable mould is composed of vegetable bodies, and it may again be transformed into others of the same or of a similar nature; it is frequently prepared very carefully with a view to this end."

Humus bears some analogy to the bodies from which it is produced, as well as to their constituent parts; but the elementary substances enter into a fresh combination, and some portion is evaporated. According to Saussure, humus contains less oxygen but more carbon and nitrogen than the vegetables from which it is derived. But the circumstances under which it is formed will, doubtless, have no slight influence upon the proportions of its elements and the various combinations which take place between the elementary parts. Thus, for example, humus formed in the open air will not be exactly similar to that which has been formed in a confined place where the atmosphere could not come in contact with it; neither is it the same when placed where it can imbibe a great deal of moisture, as it would have been if kept in a drier place. All these are self-evident facts, although as yet neither the circumstances which influence the formation of humus, nor the deviations attendant on them, have been sufficiently analyzed.

Even when the humus is formed it is not beyond the reach of alteration and destruction, as it is in constant action and reäction with atmospheric air. When placed under a receiver closed with mercury, it forcibly attracts the oxygen gas, communicates carbon to it, and changes it into carbonic acid gas. If the receiver is closed with water, it creates a vacuum, into which the water penetrates by

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Even when the humus is formed it is not beyond the reach of alteration and destruction, as it is in constant action and reäction with atmospheric air. When placed under a receiver closed with mercury, it forcibly attracts the oxygen gas, communicates carbon to it, and changes it into carbonic acid gas. If the receiver is closed with water, it creates a vacuum, into which the water penetrates by

* Humus is the modern term given by some chemists to the very finely divided organic matters which all cultivated soils contain. "Woody fibre in a state of decay (observes Liebig) is the substance called *humus*. The humic acid of chemists is a product of the decomposition of humus by alkalies; it does not exist in the humus of vegetable physiologists. Humus does not nourish plants by being taken up, and assimilated in its unaltered state; but by presenting a slow and lasting source of carbonic acid, which is absorbed by the roots, and is the principal nutriment of young plants at a time when, being destitute of leaves, they are unable to extract food from the atmosphere."—*Org. Chem.* p. 46.

absorbing the carbonic acid gas, and an almost imperceptible consumption of the humus is thus effected. It is probably by thus producing carbonic acid gas that the humus acts upon vegetation either directly or through the medium of the soil, especially when the stalks and herbage of the plants cover the ground so closely as to prevent too sudden an evaporation of the column of air evolved by carbonic acid gas. De Saussure found that plants filled with succulency, and half dry, recovered themselves much sooner when placed in a bed of humus, or in a soil abundantly provided with that substance, than when deposited in a poor, damp soil. From the experiments made with the receiver, some idea may be formed of the enormous quantity of carbonic acid gas which an acre of land, rich in humus, may be expected to disengage.

Humus likewise experiences another alteration, which De Saussure has also taught us to appreciate in a more particular manner. It forms a certain matter which is soluble in water, and is termed *extractive matter*. This substance may be separated from it by boiling humus which has been exposed to the air several times in water; when this decoction is evaporated, there remains a residue of a blackish, brown hue. When, after repeated boilings, the humus appears to be entirely deprived of this soluble substance, it will, if exposed for a time to the influence of the atmosphere, again yield extractive matter; but if, on the contrary, it is carefully preserved in closely stopped vessels, none of it can be obtained. According to Saussure, humus which has thus been deprived of its soluble extractive matter, is less fertile, and contains proportionably less carbon than that which has not been boiled. This author states that he witnessed the passage of extractive matter diluted with water immediately into the roots of plants; whence he infers that next to carbonic acid, this matter is best calculated to afford nutrition, and particularly carbon, to the suckers of plants. The matter of which we are speaking alters when exposed to the air; its solution becomes covered by a thick film or scum, which, when the vessel is shaken, precipitates itself in flakes, and is speedily replaced by a second. This precipitate is insoluble in water, but when united to an alkali it is easily dissolved. A considerable portion of the humus which is met with in nature appears to consist of the substance which has thus been separated and become insoluble.

Fixed alkalies almost entirely dissolve not only humus, but also that part of the extractive matter which has thus become insoluble; during their action ammonia is disengaged. This solution is decomposed by acids which precipitate an inflammable powder—the quantity of which is, however, very small in proportion to that of the humus. Alcohol does not dissolve humus—it only effects the separation of a small portion of extractive matter and resin.

Humus is not susceptible of putrefaction, properly so called—it seems rather to be in opposition to it; for the extractive matter readily enters into a putrid fermentation when separate from it, while, so long as it remains in combination with the other portions of the humus, this effect never takes place. The vegetation of plants, however, and the formation both of extractive matter and of carbonic acid, which takes place when the humus is exposed to the air, at length entirely consume that substance, if it is not renewed and replaced by the addition of fresh manure. Were not this the case, much greater quantities of this substance would be found upon the surface of the soil than actually exist there.—"The destructibility of this vegetable earth," says De Saussure, sen. "is an undeniable fact; and those agriculturists who have endeavored to avoid the necessity of manuring their land, by bestowing repeated plowings upon it, have been convinced of this fact by painful experience. They have seen the soil become gradually more and more exhausted, and their fields rendered sterile and barren, by the absence of vegetable mould." Probably he here alludes to the experiments made by his countryman, Chateauvieux, near Geneva, on the practice of sowing in rows or lines without manuring, which is recommended by Tull, and described, at very great length, by Duhamel, in his treatise on the cultivation of land. In order to prevent the exhaustion of the humus, it is only necessary to restore to the soil, by manuring, some portion of the elements which have been taken from it by the vegetation; because this latter produces so much more than it absorbs, that, if all which grows on the land were decomposed by putrefaction, the accumulation of humus would be immense, as is the case in ancient forests and uninhabited plains, the situations of which are favorable to vegetation.

Humus produces different effects, according to the kind of soil with which it is incorporated. Clay, by means of its tenacity, retains the particles of humus which are mixed and incorporated with it, and protects them against the influence of the atmosphere, and, consequently, prevents them from being so speedily decomposed. It is on this account that clay must be impregnated with a great deal of humus before it will evince any great degree of fertility, because the roots of the plants cannot penetrate so easily into this kind of soil. When such land is cultivated for the first time, and is not endowed by Nature with any great depth of humus, it requires repeated and plentiful manurings; but, where it is impregnated plentifully with that substance, it will retain its fertility for a considerable period without requiring fresh manure. Clay appears to enter into so close a chemical combination with humus, that the latter in some degree loses its properties, and especially its black hue. We have analyzed some clays which were nearly or quite white, and in which we could not perceive any traces of the presence of humus; when submitted to a tolerable degree of heat, they became black, and various appearances attending them served to prove that they contained hydrogenated carbon; when exposed to a still greater degree of heat, the black hue disappeared, and the clay lost a considerable portion of its weight. It frequently happens that land which is irrigated by the influx of neighboring rivers or seas, appears to be perfectly white, although its great fertility might lead us to infer the presence of a considerable proportion of humus, or, at any rate, of those substances of which humus is composed. In land thus watered, the humus is almost invariably found intimately combined with the clay; this mixture is effected by the water, which washes up the humus and deposits it in the form of mud.

Sand exercises a purely mechanical action on humus; the absence of cohesion between its parts, by which it is distinguished, facilitates the free admission of atmospheric air to every portion of the humus—favors the separation of carbon under the form of carbonic acid, and also the separation of the extractive matter, and decomposes the humus much sooner. When humus is properly mixed with sand, without any want of humidity, the land thus composed is exceedingly fertile; but this fertility is exhausted more speedily because the humus is more promptly absorbed. In the marshes of Odor there are places where, ten or twelve years ago, a very thick layer of humus covered the sand which had been washed up by the action of the water; this has been exhausted and evaporated so completely that now nothing is to be seen but loose sand. In the spring, however, even these sterile places are covered with beautiful green turf, which is very remarkable, and can only be explained by considering the quantity of carbonic acid gas which is evolved in these places. Land which contains an excess of humus is benefited by being submitted to a long course of cultivation. If sand is mixed with the spongy and pulverulent humus which accumulates, without the addition of elementary earth, such an admixture tends greatly to ameliorate it; the sand imparts a degree of consolidation to the humus, and renders it less spongy: it does not then absorb so great a quantity of moisture, and gives more consistency and solidity to the roots of the plants which vegetate in it. This has been proved by the results of those experiments in which sand has been used to improve the land, and where the benefit derived from this practice has been even greater than that which might have been expected from manuring. Sand, likewise, is capable of decomposing acid humus and peat, or rather it aids in depriving these substances of their superabundant moisture, and they are then decomposed by the action of the atmosphere.

Humus which has been for a considerable time withdrawn from the influence of the air is capable of producing very different effects from those produced by that which is exposed to the atmosphere; and this is the case whether the former state results from the hidden portion of humus having formed the lower part of a very thick bed of that substance, or from its having been covered with water or earth. This point has not, as yet, been sufficiently inquired into; we are only able to conjecture what may be the nature of the changes which the humus undergoes when thus withdrawn for a considerable time from the influences of the atmosphere; but that it does possess peculiar properties there cannot be a doubt, although it contains no acid.

It is probable that the carbonic acid and extractive matter cannot be formed or

exist without the concurrence of atmospheric air. Most likely a portion of the hydrogen and oxygen is transformed into water, while another portion of the hydrogen dissolves some carbon and evaporates in the form of hydrogenated carbonic acid gas. There is no doubt that, while the humus is buried in the earth, less of the carbon than of any of the other elements is taken from it; whereas, when this substance is exposed to the air, an exactly opposite effect takes place.

The longer the humus remains covered, the more does it abound in carbon. It undergoes a species of gradual carbonization. The lowest strata which were formed prior to those which are nearer the surface, have a more carbonous appearance; they are blacker, more compact, and when burnt yield more coal than those nearer to the surface. But if the carbon is only soluble when in combination with hydrogen, it follows, of course, that this humus must be more difficult of decomposition, and will consequently be inert, or, at any rate, less efficacious than the other, until a longer contact with the air has again changed its nature. In fact, experience teaches us that when mixed with recently made manure which emits a considerable quantity of ammonia, this humus becomes much more speedily efficacious; in fact, its effects on the soil are frequently not at all perceptible until the land has been ameliorated with dung.

But its decomposition may also be effected and accelerated by the action of lime; and as a layer of earthy lime produced by shells is frequently found under this substance, the combination may sometimes be very easily effected. Almost the same may be observed with regard to humus or mould which has been under water. If the water only superficially covered it, so that it occasionally became dry, and, consequently, was brought into contact with the air, the effect is the more speedily produced.

When humus remains constantly damp, without, however, being covered with water, it forms a very unpleasant-smelling acid, which is more particularly characterized by the property which it possesses of coloring blue litmus paper into red. This circumstance has long been known, and it is the reason that land and meadows which are not properly drained, and which exhibit these phenomena, are called "*sour*." We have carefully examined these facts, and have endeavored to discover the peculiar construction of this acid. At first we were inclined to regard it as being of a distinct nature, and having carbon for its base; but we have since become convinced that it is generally composed of acetic acid, and occasionally contains a portion of the phosphoric. This latter always adheres so firmly to the humus that it cannot be separated from it either by boiling or washing. The liquid in which the humus is boiled certainly acquires a slight acid flavor, but the greater part of the acid remains attached to the humus. All that the water is able to dissolve is a small quantity of brown matter, which, when dry, is very brittle, differs materially from the ordinary extractive matter of humus, and does not possess the power of precipitating itself from its solution when exposed to the air. This sour or acid humus contains a great quantity of insoluble extractive matter, which frequently constitutes the chief part of its weight. When steeped in an alkaline lye, this latter becomes of a dark brown hue, and is thickened by the dissolution of several substances. If this mixture is diluted with an alkali, the extractive matter is precipitated in brown flakes; and what is very remarkable, if more acid is added than is absolutely necessary to neutralize the alkali, it again absorbs the acetic and phosphoric acids, and resumes its former state. But if only so much acid is allowed as will suffice to saturate the alkali, the former remains combined with the latter in the solution, and the extractive matter loses every particle of acid.

This acid or sour humus, is not at all of a fertilizing nature; on the contrary, it is prejudicial to vegetation. Where it is very strong and pervades the whole of the humus, the soil only produces reeds, rushes, sedge, and other useless, unpalatable plants; wherever these abound, it may be inferred that the soil contains a great deal of sour or acid humus.

When land has been drained and deprived of that excess of humidity which is so favorable to the formation of acids, there are various means of getting rid of this baneful property and of rendering the humus fertile. When this has been done, such places will be found to contain rich stores of nutritious vegetable substances concealed there by nature, and which may be either used on the spot or carted and carried to the fields as a manure. It is well known that with the aid

of alkalies, ashes, lime, and marl, humus may be deprived of its acidity and rendered easily soluble; should these substances not be within reach, a very efficacious remedy will be found in the humus itself; it is only necessary to burn it, and thus derive the exquisite lime and alkali from the humus itself. Besides, the fire has the property of destroying the greater part of the acidity. This is one reason why paring and burning is generally so beneficial to soils of this nature.

This acid humus is produced by those vegetables which contain a considerable portion of tannin, or, at any rate, something similar to it, and especially by heaths or furzes, even when they vegetate on a dry situation. In places where this family of plants abounds, a soil is frequently found, the deep black color of which is essentially owing to the humus; although, to all appearance, iron also has a considerable share in producing it. This kind of humus is absolutely insoluble, and only favors the vegetation of those plants whence it proceeds, and they do not thrive anywhere else; heaths, &c., do not thrive in places where this humus does not exist, and when they have once established themselves in one particular spot, they suffer few other plants to appear. This humus may be changed by a dressing composed of marl, lime, or ammonia; and where this has been mixed with the soil, the heaths, &c., speedily perish. Paring and burning is also productive of some good; but it is difficult to keep up a sufficient fire to produce the requisite degree of combustion.

The leaf of some trees, and particularly that of the oak, will likewise produce humus of this nature, if, before its putrefaction, it is not decomposed by very hot animal manure, or by lime and alkalies. Nevertheless, when this substance is exposed to the air, it gradually loses all its baneful properties, and is at length transformed into good humus; but a considerable time must elapse before this effect is produced.

It also appears that in recently formed humus there is a considerable difference between that which is the residue of complete putrefaction, and another portion, the elements of which have only been partially decomposed. This difference has not as yet been sufficiently examined. The former, however, evidently appears to contain a smaller portion of coal; when fire is applied to it, smoke only is given out; while the latter is blacker, possesses more coal, and, consequently, burns more briskly and disengages a larger portion of caloric. In ancient marshes which have been drained or otherwise become dry, a kind of humus is often found which greatly resembles rotten wood, and which, to the depth of a foot and a-half or two feet, forms the principal constituent part of the soil. Land of this nature, although rich in nutritive juices, is not favorable to Agriculture or to the growth of cereal plants. I am not yet quite sure whether this arises solely from the soil not possessing sufficient consistency, or whether it is attributable to some peculiar quality possessed by this kind of humus.

Lastly, all humus, and especially that which has been recently formed, possesses essentially different qualities when resulting from the decomposition of vegetable bodies from those which distinguish it when formed by animal decomposition. In the latter case, it contains more nitrogen, sulphur, and phosphorus; the presence of which bodies is rendered quite evident by the odor which it emits when burnt, which is similar to that which arises from the burning of animal bodies.

PEAT.

Peat is also a species of humus. There have been various opinions relative to the origin and nature of this substance. Formerly, a mineral, or, at any rate, a semi-mineral origin was attributed to it; and it was believed to be a mass united and mingled together by bituminous particles: but this opinion is now altogether exploded. It is true that some kinds of peat are met with which are strongly impregnated with bitumen, but there are others which do not contain any portion of this substance; and even if it were present, it is now well known that bitumen derives its origin from the mineral kingdom. Peat is neither more nor less than the remains of plants in a state of greater or less decomposition. It is found in low, moist situations, where mosses, lichens, and other plants grow, which are with difficulty decomposed; these become interwoven and unite with the mud and various substances deposited by the water; the whole amalgamates—

the vegetables putrefy and gradually lose their organic texture, and are at length united with the other substances in a compact spongy mass. When the putrefaction is so far advanced that the organic tissue is totally destroyed, the peat is neither more nor less than a kind of humus—that is to say, a sour humus; but while it contains some degree of consistency, and is not too much mixed with earth, it may be used for the purpose of burning. The plants of which turf is formed, and by means of which it increases in thickness, are those only which grow in moist or wet places, viz. sedge (*carex*), cotton-grass (*eriophorum*), marsh ledum (*ledum palestre*), &c. Van Marum, a Dutch naturalist, regards the *conserva*, or hair-weed, as one of the principal elements of peat; and is so much convinced of this fact as to assert that any soil may be rendered peaty by merely naturalizing this plant on it in some moist situation.*

The circumstances under which peat is formed are subject to considerable variation: the position of the soil with respect to the surrounding country, and especially with relation to the neighboring lakes and rivers; the degree of humidity which these latter engender; the nature of the plants which constitute the elements of the peat; and, lastly, the substratum of the soil—all these things may differ in different places; and hence, without doubt, arise all those varieties which we find existing in peat.

In a situation where everything tends to accelerate the progress of decomposition, the peat is found existing in a homogeneous, heavy, black mass; while in others, where decomposition takes place more slowly, it is met with in light fungous pieces, in which are portions of semi-decomposed filaments of plants and vegetables; and, again, in other places it is found entirely composed of bitumen. Peat also presents several other irregularities and variations, which are more or less evident, and some of which can only be discovered by the most minute examination. It will often be found to be quite different in the same place, being soft and filamentous at the top, and becoming compact, solid, and black, as we penetrate farther into it. This may easily be explained: the peat has not been formed all at once, but gradually, and in successive layers; when one generation of plants perished, another sprang up from its ashes, and thus the mass has been gradually increased. The substrata are, therefore, more ancient than the superior ones; the decomposition is farther advanced in the former than in the latter; and in proportion as this is the case, or the higher the state of carbonization in which the plants are found, the inferior layers will necessarily be more putrefied, black, and carbonous.

The greater the degree of decomposition of the vegetable fibres, the more nearly does peat assimilate to humus. The only difference which exists between it and the humus which is found in fields, forests, and uncultivated places, is in the cause to which it owes its existence. Besides, humus, which is formed by the decomposition of, or putrefaction of, vegetable bodies, is not exposed to so continuous a state of humidity as peat; the earth of the soil with which it is mixed acts upon it, while that substance does not exist at all in peat, properly so called. In the greater number of cases, peat is very much like acid or sour humus; in-

* The formation of bog-moss is first commenced, in very many instances, by the rapid-growing, broad-leaved bog-moss (*sphagnum latifolium*), a plant of very curious habits, whose growth, under favorable circumstances, (and it is strictly an aquatic,) extends from an inch in length to two or three feet. In dry situations, or in those only periodically flooded, its progress is not rapid; but when it vegetates, always immersed in the water of low stagnant situations, there it increases with great vigor. It is true that this plant is an annual; but it sheds an abundance of hardy seeds, producing seedlings, which vegetate and easily support themselves in the water, with a slight assistance from the mere remains of their preceding generation.—Their thread-like stems remain on the surface of the water till the seed is ripened; they then fall to the bottom and form distinct layers, which, in some specimens of peat, may be distinctly traced. The bog-moss, thus commenced, gradually gets mixed with a variety of lichens, mosses, and scirpi, which annually add to the depth of the accumulating peat; and, as the moss becomes firmer, other plants gradually establish themselves, such as several varieties of the rushes and sedges. It is only when the peat-moss is raised, by the gradually-accumulated remains of these peats, from beneath the surface of the stagnant waters, that the heaths, the cranberry, the bilberry, and the grass-weeds, make their appearance. The few plants which commonly tenant peat moors and bogs are of the most worthless kind, such as all live-stock commonly refuse. Besides the common heath plants, there are various rushes (*juncus*), sedges (*carex*), rush-grasses (*schœnus*), club-rushes (*cyperus*), cat's-tail-rushes (*typha*), bur-weeds (*sparganium*), &c.

Among the few specimens of the common grasses which are found in such places, struggling, as it were, for existence, are the marsh-bent (*agrostis palustris*), the awnless brown-bent (*agrostis canina*)—this is a very common grass in bogs whose winter waters are deep—the awned creeping-bent (*agrostis stolaris*), the small-leaved creeping-bent (*agrostis stolaris ang.*), the creeping-rooted bent (*agrostis repens*), the white bent (*agrostis alba*), the flote fescue (*glyceria fluitans*), tall fescue (*festuca elatior*), turfy hair-grass (*aira cæspitosa*), knee-jointed fox-tail grass, water hair-grass (*aira aquatica*), water meadow-grass (*poa aquatica*), long-leaved cotton-grass (*eriophorum polystachion*), and the sheathed cotton-grass (*eriophorum vaginatum*).

deed, it sometimes resembles it so strikingly that it is impossible to distinguish these substances apart. Peat, like sour humus, contains acetic and phosphoric acid and ammonia; and, even when it does not contain acid, it possesses a great quantity of insoluble extractive matter, which can only be rendered soluble by an admixture of potassa and acids. Pyrites have occasionally been found in peat; these substances have, doubtless, been introduced externally, but by what means is as yet unknown. During combustion it emits a sulphurous odor, and likewise sometimes produces upon its surface a salt which smells like ink, and is no other than sulphate of iron or vitriol.

The constituent parts of turf, like those of humus, are carbon, hydrogen, nitrogen, and oxygen. All peats do not contain an equal quantity of carbon. The older the peat is, the more of this substance does it possess; and as, when used for burning, its quality depends upon the quantity of carbon contained in it, it follows that the older it is the better is it adapted for that purpose. When exposed in a dry place, and mixed with potassa or lime, it becomes decomposed, is freed from its acidity, and transformed into a mild fertilizing humus.

Another combustible substance which is sometimes found at a small depth below the surface of the soil, and occasionally beneath peaty marshes, is *coal*, or *bituminous wood*. Coal not only serves as a combustible, and is useful to the agriculturist in enabling him to calcine lime, but it also appears to yield a species of manure which is most active when mixed with sulphurous pyrites and iron, because the decomposition of the former creates vitriol, which, when a small portion of it in this combination is spread over the land, appears to have a favorable effect upon vegetation.

THE DIFFERENT SPECIES OF EARTHS—THEIR VALUE, EMPLOYMENT, AND PROPERTIES, IN THEIR RELATIONS TO THE CONSTITUENT PARTS OF THE SOIL.

Each of those substances of which we have been speaking would, if alone and isolated, constitute a sterile soil, or, at any rate, one totally unfit for the purposes of Agriculture. The quality of a soil results almost entirely from the proportions in which these earths are united in it, and the infinite variety of these proportions gives rise to the innumerable kinds of soils which are met with in nature, and which are not separated from one another by any limits or line of demarkation, but merely by almost imperceptible shades of difference.*

Hitherto, the various kinds of land have been classed in a practical manner, according to the degree of fertility observed in them, and the species and value of the products which could be obtained from them. But this mode of classification has been considered defective; and such it necessarily must be, so long as it continues to be founded on any other basis than a sound knowledge of the constituent parts of the soil. Where attempts have been made to class different kinds of land according to their constituent parts, sufficient attention has not been paid to their fertility and to the effects produced when they are cultivated; but no decisive experiments appear to have been made on this subject. We have chemically analyzed several kinds of soils, and at the same time have endeavored to obtain some more accurate knowledge of the effects produced by each of them upon Agriculture and vegetation generally. The results of our attempts have certainly enabled us to throw more light upon the subject than other authors

* To a certain extent, it may be taken to be the fact, that the richer soils have the least specific gravity.—In the experiments of Rev. W. Rham, a good garden mould, consisting of—

Clay	52·4	Carbonate of lime	2·0
Silicious sand	36·5	Organic matter	7·3
Calcareous sand	1·8		

had a specific gravity of 2·332.

A good loam, consisting of—

Clay	51·2	Carbonate of lime	2·3
Silicious sand	42·7	Organic matter	3·4
Calcareous sand	0·4		

had a specific gravity of 2·401.

A poorer soil, of which the component parts were—

Silicious sand	64·0	Carbonate of lime	1·2
Clay	32·3	Organic matter	1·3
Calcareous sand	1·2		

had a specific gravity of 2·526.

To those who may be inclined to try the analysis of soils, it may be interesting to compare the results of their own experiments with some which have been obtained with great care. Thaër has, in another place, given a table in which different soils analyzed by him are classed according to their comparative fertility—

have done, but there still remains a wide field for inquiry and research. Thus, then, although the following remarks must be merely regarded as a primary and, consequently, imperfect attempt to distinguish and class the different kinds of soils, yet I cannot but regard them as useful, if they merely serve as lights to warn us of errors, and point out the path which will lead to a clearer and more thorough knowledge of the subject.

In the ensuing estimation of soils, valued according to their constituent parts, I shall suppose them all to be equal in every other respect, viz., with regard to position, depth, humidity, &c. &c.; and shall afterwards consider the influence of all these circumstances separately.

The humus is, as we have already observed, that portion of the soil from which plants derive their nutriment. The richness of a soil, or that quality which it possesses when it is said to be fat, depends essentially upon the proportions of humus which it contains, although many persons understand the term "fat," to apply to land of a more or less argillaceous nature. Humus also exercises a physical action upon the soil; it renders argillaceous land or stiff clay more porous, facilitates the action of the atmosphere upon it, and tends to loosen and pulverize it; it gives consistence to, or consolidates, sandy soils, and when mixed with them enables them to retain moisture. This substance has likewise a very beneficial effect upon land which contains too great a proportion of lime, rendering it milder, less irritating, more consistent, and preventing moisture from evaporating from it too easily.

This fertilizing matter may, however, exist in too large a quantity. Where this is the case, the soil is too friable and spongy, and is not sufficiently consolidated to enable it to yield a firm support to the roots of the plants which vegetate in it; it absorbs water like a sponge, and, when the weather is damp, becomes so saturated with moisture that it almost resembles a marsh; consequently, those plants which are sown in it are subject to all the evils entailed on them by superabundance of humidity, and either become diseased or perish. In dry weather, on the contrary, such a soil allows the moisture to be too easily evaporated, and then its surface becomes so dry and pulverulent that the seeds sown in it cannot germinate, or, what is worse, they dry up and perish after having germinated; while at the depth of some inches, where the atmosphere cannot penetrate, it remains so wet, that if a portion be squeezed in the hand, water will drop from it. Besides this property, a soil which is surcharged with humus, will, at each sensible change of the temperature, contract or dilate; thus detaching the roots of the plants from their hold, and frequently throwing them up so much that nothing but the mere extremity remains attached to the soil. Land of this nature is less adapted for autumnal than it is for spring corn, and oats answer better on it than barley, because they are stronger and more tenacious. Lastly, it favors the growth of all kinds of weeds which vegetate in it so rapidly that they totally choke the cereal plants.

A soil which contains too great a proportion of humus, however good and mild that substance may be, can only be rendered profitable by being used to improve and ameliorate poorer lands.

which is expressed in numbers—100 being the most fertile. This table is the result of very patient investigation—the natural fertility of each soil being ascertained by its average produce with common tillage and manuring. It is as follows:

Clay.	*Sand.*	*Carbonate of Lime.*	*Finely divided Organic Matter or Humus.*	*Comparative Value.*	
74	10	4	11½	100	
81	6	4	8½	98	Rich alluvial soils.
79	10	4	6½	96	
40	22	36	4	90	
20	67	3	10	78	
58	36	2	4	77	
56	30	12	2	75	Good wheat and barley lands.
60	38	Very little carbonate of lime.	2	70	
48	50		2	65	
68	30		2	60	
38	60		2	60	Barley land, not fit for wheat.
33	65		2	60	
28	70		2	40	
23½	75		1½	30	Poor sand, fit only for oats or buckwheat.
18½	80		1½	20	

If it is tolerably humid, it will often be profitable to transform it into meadow land, and then, if not inclined to be marshy, it will soon yield very rich pasturage, especially if sown with proper gramineous plants, as the *alopecurus pratensis* (meadow fox-tail grass) and the larger varieties of the *poa* and *festuca*. If dry, it may be ameliorated by means of additions of poorer soils, or, what is still more easy, by incineration, or paring and burning, which consumes and transforms a portion of the excess of humus contained in it into ashes; but after this operation has been performed, care must be taken that the corn does not fall or become lodged so early as to be spoiled.

Clayey or argillaceous land can bear a greater proportion of humus without injury than any other kind, because the properties of the clay correct those of the humus. I shall not venture to decide what is the precise degree to which the addition of humus increases the value of clay soils. The richest land I ever analyzed, and which was taken from the marshes of the Oder, contained 19¾ parts in a hundred of humus, 70 of clay, a little fine sand, and an almost imperceptible quantity of lime; but the situation of this land was too low, and it was too damp to admit of a correct estimate being formed of its fertility. Autumnal corn could not be raised there at all, on account of these circumstances; and the success of the spring crops was always uncertain. Upon the whole it was tolerably consistent, and possessed a sufficient degree of cohesive attraction for water. I have never found more than 11½ parts in a hundred of humus in any other clayey soil; not even in what is called "fat land." But I have never yet had an opportunity of examining or analyzing any of those inexhaustible soils which are capable of bringing the crops to full maturity every year without being manured, and in which no diminution of fertility is observable so long as the requisite degree of cultivation is bestowed on them; nor of analyzing those soils which are said to be deteriorated rather than improved by manure.

It is asserted that such land is to be found in the Ukraine, in Hungary, and in several other places, and that some few circumscribed portions of it are to be found even in Germany. Several soils which we have analyzed, were once considered to be inexhaustible; but when they came to be broken up for the first time and brought into cultivation, it was generally found that, after bearing a series of crops, most of which were suffered to arrive at maturity, they required manuring, if not laid down for grass or meadow land, in order to give them time to recruit their exhausted energies and regain their succulency, or plowed or dug up with the spade sufficiently deep to bring to the surface the under layers which had not been touched. There are now very few countries in which it is thought possible to go on entirely without manure, and in these the land is usually devoted more to grass and to the feeding of cattle than to the cultivation of corn. The richest argillaceous soil that I ever analyzed, the fertility of which was regarded as of the very richest quality, was taken from the right bank of the Elbe, some few miles from its mouth; it contained eleven and a half parts in a hundred of humus, four and a half of lime, a great quantity of clay, a little coarse silica, and a considerable portion of very fine silica, which could only be separated from it by ebullition. It certainly possessed a great degree of cohesion, but when moderately moistened it was not very tenacious. It was made to bear the richest crops, as cabbages, wheat, autumnal corn, beans, &c. but every sixth year it was necessary to manure it thoroughly and to give it a fallow.

We have found humus mixed in various proportions with clay in those low lands, which, when submitted to a judicious rotation, are so very fertile. A portion of land in Budjading, the whole of which country is regarded as particularly fertile, contained 8 2-5 parts in a hundred of humus, three or four of lime, and the rest was almost pure clay. The land of the bailiwick of Wallup, which contains 6¼ parts in a hundred of humus, is also excellent land for wheat, since it will produce three crops of that kind of grain after having been manured, and all equally fine, strong, and plentiful.

We must not always suppose that because the soil is of a dark color it contains a large proportion of humus; sometimes land of a whitish hue contains considerably more humus than that which is brown, or nearly black; but, if a light-colored soil be submitted to incandescence in a closely stopped crucible, the dark hue will speedily develop itself if the soil contains humus.

These rich argillaceous lands are only met with in low situations, valleys,

near the beds of rivers, or other places, where the inundations of water have deposited a layer of mud of greater or less thickness; as, for example, in valleys which once constituted lakes before the waters dried up or were turned off in some other direction, or on the margins of rivers whence the water has gradually retired as the course of the stream became altered. Land of this nature is generally entered in the first class, under the denomination of *rich wheat land*, because, in the triennial rotation with a fallow, it can bear three crops of wheat without requiring fresh manure.

Soils comprised in this class have different degrees of fertility and value. I shall not permit myself to determine whether or not they ought to be estimated solely with relation to the proportion of humus which they contain: comparisons with respect to fertility where the lands lie at considerable distances from one another are difficult; and, besides, the fertility depends so much upon climate and temperature. Neither can I positively state whether or not the greater or less proportion of lime and animal matter which are so often mixed with the soil, may not have some influence upon its fertility.

From the results of my inquiries and experiments, I think that I may venture to assert that a vegetable soil ought to contain at least from five to six parts in a hundred of humus, to entitle it to be comprised in this class. In order to designate the proportions of the value of different soils, we shall fix that of the most fertile at a hundred; but this value will necessarily be increased or diminished by the influence which situation, climate and other concomitant circumstances exercise on the utility of land.

Land in which humus is combined with a small portion of clay and a large quantity of sand, must not be comprised in this class; the compost which results from this mixture possesses little cohesion, more readily allows the admission of heat and moisture, and at the same time permits them to be carried off with greater facility. Here the proportion of humus may easily become too great. We have analyzed a soil which contains twenty-six parts in a hundred of humus, and the rest equal parts of sand and clay; it was very friable and little adapted for the cultivation of corn. When drained and broken up, the first crops which it bore were very rich, but its fertility rapidly diminished; and, although every attempt was made, by means of abundant manurings and ameliorations, to restore to it that which it had lost, it never regained its original fertility.

On the other hand, another soil which was still more sandy and contained about ten parts in a hundred of humus, appeared to us exceedingly fertile and well adapted for every kind of cereals excepting wheat, especially after it had been laid down as pasturage for several years. This land, however, required a great deal of manure, and was never so profitable as when manured before the last crop raised upon it previous to its being laid down for grass. Experience proves that land of this nature may easily be exhausted, if not manured and allowed some period of repose. We do not as yet know what proportions of clay it ought to contain in order to ensure the success of repeated crops of wheat. If it contains twenty parts in a hundred of pure clay, ten parts in a hundred of humus, and the rest sand, it produces excellent barley; when it contains less clay, the crops of oats are not so casual, if the climate and temperature be humid; the rye crops too are abundant, provided that the seed is sown sufficiently early to gain strength enough to withstand the winter.

Land should chiefly be valued according to its consistence: the greater the degree of this quality which it possesses, the nearer does it approach in value to that assigned to first class land, viz. 100; but the smaller the proportion of clay and the larger the quantity of sand which enters into its composition, the more rapidly does it fall in value to 80, even when it contains from ten to fifteen parts in a hundred of humus. This kind of land is only found in plains or valleys, or near the beds of rivers, and is seldom deficient in humidity. There the humus has been formed by the decomposition of those aquatic plants which were constantly re-produced for centuries in the water which formerly covered these low lands: when the water subsided or disappeared, the plants entered into a state of putrefaction of greater or less duration: it is the duration and inequality of this putrefaction which causes the humus to appear to contain a greater or less quantity of carbonic acid.

In both the kinds of land which we have been considering, we have supposed the humus to be mild, that is to say, exempt from acidity. Sour or acid humus totally destroys the fertility of a soil; sometimes, however, the soil contains so very small a portion of acidity that its fertility is very slightly diminished, and only with regard to some few plants. Barley crops become more and more scanty in proportion as the acidity is increased; but oats do not appear to be at all affected by it. Rye grown on such land is peculiarly liable to rust, and is easily laid or lodged: the grains of all the cereals become larger, but contain less farina. Grass which grows on these spots is, both in species and taste, less agreeable, and less suitable for cattle, than any other, although it yields a very considerable produce in hay. In fact, in exact proportion with the increase of acidity, is the decrease in the value of the soil, and this goes on from bad to worse until the soil is no better than what we call marshy land.

A blackish hue on the soil usually induces the supposition that it contains an abundance of humus; and, in the majority of instances, this opinion will prove correct, unless the color arises from the presence of oxide of iron, or manganese; the remarkable fertility of land colored by humus does not admit of its being long mistaken.

All doubts upon the subject may, however, soon be removed by submitting a ball of the earth in question to incandescence in an open crucible, which will allow the atmospheric air to come in contact with it; in this case, if the dark color arises from the presence of humus, it will speedily disappear, and the earth will become quite white, an effect which is not produced when the dark hue arises from oxide of iron. The simplest means of ascertaining and estimating the quantity of humus contained in a soil is to burn it. A certain portion of the soil which we wish to analyze, taken not too near the surface, should be dried in the sun until it pulverizes in the hand and feels quite dry; the small stones should then be picked out, and the remaining portion accurately weighed, placed in a crucible, heated to a perfect state of incandescence, and kept in that state for about ten minutes, or at least until the black hue has entirely disappeared, and gently moved or stirred with a glass tube all the time. In order to accelerate the total combustion of the humus and shorten the operation, a small portion of nitrate of ammonia may be united with the earth, which completely volatilizes that substance. The diminution of weight will indicate the quantity of humus which the soil contained. There is no doubt that the earth, especially if it be of an argillaceous nature, loses some of that water which was so closely united with it, to be evaporated only by the process of incandescence; but this will make a very trifling difference in the weight, and if the earth was previously well dried, it will not amount to a fraction. But where the soil contains a good deal of lime, the volatilization of its carbonic acid as well as of its water of crystalization, will cause a sensible difference in the result of the experiment; it is, therefore, highly necessary to begin by getting rid of the lime. The acidity of humus may be detected by immersing a strip of blue turnsole paper in a liquid paste, formed of the earth we wish to analyze, and water. If the paper turns red, that may be considered as a certain sign of the presence of an acid. Sour or acid humus also betrays itself by the peculiar odor which it emits when burned, an odor similar to that given out by burnt turf. If humus, when burning, smells like burnt feathers, that is a sign that it originates in animal matter, and is, consequently, richer, and may be more easily decomposed.

There is no doubt that a more definite analysis of humus might be effected by means of the pneumatic apparatus, and by dry distillation; but an agriculturist has it not always in his power to perform this operation. Arthur Young frequently performed these experiments, and found that the quantity of hydrogen gas which he obtained was always in exact proportion with the fertility of the soil. The experiments conducted by Priestly were attended with similar results, and serve to confirm this fact.

Clay increases the fertility of the land: 1. By the adhesion which it contracts with water. This adhesion is so great, that, even during a long drouth, the clay always preserves that humidity which is indispensable to the nourishment of plants; and, although it may appear to be entirely parched up, it is still capable of communicating to them that moisture without which they could not exist. 2. By the solid support which it affords to the roots of plants, as well as by the

resistance which it opposes to their too great extension, obliging them to put forth several tufts of short fibrous roots, by means of which each plant seeks its nourishment in the circumscribed spot; and, consequently, does not deprive its neighbors of their fair share. 3. By preventing the atmospheric air from coming in contact with the roots of the plants, to which it is almost invariably injurious, and by communicating to them a moderate and equable degree of warmth; thus preserving an equality of temperature, notwithstanding the constant changes going on in the atmosphere. When argillaceous land is not too damp, the effects of sudden changes from hot to cold, or *vice versa*, are, consequently, less injurious to the crops growing on it, than they are to those which grow on sandy soils. 4. It attracts oxygen, the substance which is so necessary to the formation of carbonic acid. It probably attracts nitrogen also; and thus favors the reciprocal action of these substances upon each other.

On the other hand, an excess of clay is injurious: 1. Because in damp weather it retains the water with which it is impregnated too long, neither suffering it to drain out or evaporate, but forming with it a tenacious paste. 2. Because in dry weather it becomes too hard, opposes too great a resistance to the roots of the plants, and, not unfrequently contracts and becomes not unlike a mass of brick. 3. Because, both during the summer heat and the winter frost, it cracks into gaps or clefts, by which means the roots of the plants are torn or brought into immediate contact with the atmospheric air, which is generally injurious to them. 4. Because it forcibly attracts and incorporates with itself all the nutritive juices contained in the manure bestowed upon it, and cannot be made to part with them again so easily as in looser and lighter soils. In fact, when it has once been thoroughly ameliorated, and in a manner saturated with manure and brought into good condition, it retains its fertility for a considerable period: but, if once impoverished or exhausted, the first manurings bestowed upon it have little or no effect upon the vegetation. Land of this nature, therefore, must be manured very plentifully, or the first crops derive little or no benefit from the amelioration. 5. Because it renders the task of cultivating the soil exceedingly difficult. In damp, wet weather it is almost impossible to pass either a plow, harrow, or wagon over it; it sticks to the two former instruments, clogs them, and impedes their action, and can with difficulty be divided; while in dry weather it contracts and becomes so hard that it is with the greatest difficulty a plow can divide it even into large clods, and these, until they have been moistened by rain, can neither be broken by the harrow or the roller, and, not unfrequently, a mallet is obliged to be used for this purpose, and even then the end in view is but very imperfectly attained.

The injurious effects of an excess of clay may, in part, be counteracted by the addition of humus; but, as we have already stated, this will not entirely obviate them. Lime is also rather beneficial in this case, as we shall presently see. But nothing is so really beneficial as sand, and that is the substance which is generally used. The superior layer of the soil always contains some portion of sand; and, were not this the case, it would be scarcely possible for any agricultural implement to act upon it. Consequently, the estimation of most lands ought principally to be based upon the proportions in which clay and sand are united in them.

Previously to pointing out what these proportions are, I must, in the first place, explain precisely what I mean by sand. My intention is to designate, under this term, that coarse-grained silica which, when any portion of earth is carefully washed, is precipitated to the bottom of the vessel, and can there be collected. Recent experiments have shown us that, when clay is boiled in water, a considerable quantity of fine-grained silica is separated from it; and that, if this operation is prolonged and carefully performed, the alumina will at last be deprived of nearly the whole of its silica. It appears that the quantity of this fine silica constitutes the principal difference which exists between rich and poor clay; that clay, properly so called, is always composed of the same proportions, and is not chemically combined, at least in an intimate manner, with a fixed and definite quantity of silica, although it may be mechanically united with a much larger portion. I cannot, as yet, affirm that such is the case, but I think it very probable.

As the end we now have in view is to regulate and determine the value and utility of land, according to the proportions of its constituent parts, and to effect

this purpose in the simplest possible manner, we shall not pay any attention to this fine silica which cannot be separated except by boiling; but regard clay as pure when it has been carefully washed. In by far the greater number of cases, at least fifteen parts more of fine silica might be extracted, by boiling, from a hundred parts of clay which has been purified by washing. The proportion of this substance obtained from some particular kinds of land is still greater. The experiments and researches hitherto made do not enable us to determine how far clay which contains a still greater portion of this substance is benefited by the addition of sand, and what quantity of that matter is necessary to give it the requisite degree of porousness.

When the soil is composed of almost equal parts of pure clay and of that kind of sand which can be separated from it by washing, we designate it clay land, or potter's earth; and we preserve this denomination so long as the soil does not contain more than from forty to sixty parts in a hundred of sand; and, according as this proportion is increased or diminished in it, we term it *loose* or *stiff* and *tenacious clay land.*

A soil which contains less than forty parts in a hundred of sand is called argillaceous land; the smaller the proportion of sand which it contains, the more stiff and tenacious does it become, and the more evident are the defects of the clay. Land containing, at most, only twenty parts in a hundred of sand, is very stiff and crude, and cannot be tilled without great difficulty, unless its defects are corrected by a considerable admixture of humus or lime. Its quality, however, depends in a great measure upon the nature of the clay, and the quantity of silica which enters into its composition: such a soil is less defective if, while it contains only a small portion of sand, it possesses a large quantity of silica.

When this argillaceous land does not contain sufficient humus to enable it to bear wheat without being manured afresh, and, consequently, cannot be entered in the first class, it will be termed wheat land of the second quality, or second-rate wheat land; but then it must not be totally destitute of humus. On rising grounds, or eminences, we seldom find land submitted to ordinary cultivation which contains more than three parts in a hundred of this compound matter; nevertheless, such land is well adapted for wheat, and that species of cereals succeeds much better and with less trouble than rye. Next to wheat, barley thrives best there, if the soil contains from thirty to forty parts in a hundred of sand; but when it only contains a smaller proportion, and this defect is not remedied by a strong admixture of lime, it is better adapted for oats. Such land is also exceedingly proper for the growth of vegetables, provided that it is sufficiently ameliorated; that which contains most sand is favorable to peas, while a stiffer and more tenacious soil grows beans with greater advantage.

The value of land diminishes in exact proportion with the decrease in the quantity of the sand contained in it, unless it belongs to the class of marly or calcareous soils, or to those which are strongly impregnated with humus; thus a soil containing forty parts in a hundred of sand is of the greatest value, while that which contains but five parts in a hundred is much less esteemed. A tenacious and argillaceous soil which is plentifully manured, and situated where an alternately hot and moist temperature not only favors the operations of plowing and fallowing, but also the processes of vegetation, is sometimes very superior, especially for the growth of wheat; but if we come to consider the difficulty there is in cultivating it, and how much more uncertain and casual the crops are there than they would be on a lighter soil, there can no longer be any doubt as to its inferiority in value. I estimate land which contains two parts in a hundred of natural humus, forty of sand, and about sixty of pure clay, at 70; that which only contains thirty parts in a hundred of sand, at 60; that which contains but twenty parts, at 50; and that which contains only ten parts, at 40. Should it not possess more than one part in a hundred of humus, its value is decreased at least twenty per cent. Thus, tenacious soils which contain little or no mild, soluble humus, and which is usually termed cold, damp land, is actually one of the most sterile that possibly can be, and may, in point of value, be assimilated to sandy land. On the other hand, its value is increased in proportion to the quantity of humus and clay which it contains; and such land may even be good enough to be entered in the first class, when it can be abundantly manured and properly tilled.

Land which contains more than forty, or from that to sixty parts in a hundred

of sand, is usually designated clay, or potter's earth, but the less the proportion of sand falls below forty parts in a hundred, the greater is the value of the land, supposing it to possess an equal quantity of humus. Where the proportion of sand does not exceed fifty parts in a hundred, the soil is equally adapted for the production of wheat and barley. But when that proportion increases from fifty to sixty parts in a hundred, wheat certainly may be grown there, provided the soil is properly cultivated; but the crops are never very fine or very abundant, and the land is much more impoverished than it would have been if cropped with rye: such a soil is, however, peculiarly well adapted for barley, and may be classed among the very best of those lands which are destined to bear this kind of grain.

The inherent advantages of a soil of this nature, viz., of causing the crops to be less casual and uncertain, being more easily worked and tilled, preserving a moderate degree of temperature and humidity, &c., render it so very superior to argillaceous land, that, notwithstanding its being less adapted for wheat, it may be assimilated to wheat land in all its various gradations. In this case, the gradations are in an exactly inverse direction; forty parts in a hundred of sand appearing to us to be the best proportion. In the former case, the value of the soil decreases when the proportion of sand diminishes; in the latter, on the contrary, the value decreases when the proportion is increased, but not in the same ratio. From the observations which we have hitherto been able to make the value of the soil appears to be almost equal in the following opposite proportions:—

Sand.	Pure Clay.	Sand.	Pure Clay.
50 parts in 100	50 parts in 100	35 parts in 100	65 parts in 100
60 "	40 "	30 "	70 "

That is to say, the former are defective on account of their want of consistence, and the latter on account of their too great tenacity.

This kind of land may be vigorously tilled without becoming pulverized, neither does it harden into clods and furrows; it is seldom injured by an excess of moisture, and yet preserves sufficient humidity to enable it to resist the effects of drouth for a considerable period; and young plants suffer much less in it than in tenacious soils, because their roots are better able to extend in all directions and penetrate it; and this is the reason that barley succeeds and flourishes so much better here. Such land will, doubtless, only bear fine crops of wheat when it has been thoroughly ameliorated; but, even when in a less fertile condition, it produces finer crops of rye than are grown on more argillaceous lands. It is also peculiarly adapted for vegetables, as potatoes and radishes, for clover and other kinds of fodder, and for plants of commerce, as cabbage, linseed, tobacco, &c., the cultivation of which is easy. It seldom offers any opposition to the action of the plow and harrow; and on this account, although it does not yield fine or large crops of wheat even in favorable years, it ought, in the gradations pointed out, to be assimilated to *wheat land*, properly so called.

Sand is injurious when it enters too largely into the composition of the soil: 1. Because it is not sufficiently retentive of moisture, but allows the water to evaporate or drain away, and carry with it the fertilizing particles and juices. 2. Because it does not combine with the humus, and hardly enters into a physical union with it sufficiently strong to absorb those fertilizing particles which the atmosphere contains. 3. Because sandy soils will not bear frequent cultivation, although constant tillage is necessary in order to destroy the weeds which multiply so rapidly in land of this nature, especially when it contains a fair quantity of humus; and because these repeated workings deprive it of every particle of coherence, and, instead of ameliorating, tends rather to impoverish it by bringing to the surface all that humus which was amassed in the interstices without being combined with the soil, and thus exposing it to the action of the atmosphere and the winds, which rapidly decomposes it and carries it away. 4. Because, sandy soils being good conductors of caloric, they transmit the influences of severe cold or intense heat immediately to plants at each sudden change which the temperature of the atmosphere undergoes.

A soil which contains more than from sixty to eighty parts in a hundred of sand is termed *sandy clay*. The value of this land diminishes in proportion as the sand increases; if that which contains sixty parts in a hundred is valued at 60, land containing sixty-five parts ought not to be estimated at more than 50,

seventy parts decrease the value to 40, seventy-five to 30, and, lastly, that which contains eighty parts to 20. Wheat crops cannot be reckoned upon here with any degree of certainty; and if the land contains seventy parts in a hundred of sand, it is not at all adapted for the production of this kind of grain, unless it be submitted to a peculiarly enriching course of tillage; but it is well calculated for barley, particularly when the situation is favorable and the summers are not too dry. It is easily worked or tilled, but is more liable to be overrun and infested with weeds than argillaceous soils. It has no great degree of cohesive attraction for manure, but, on the contrary, rapidly decomposes that substance, and allows it to pass into the plants which vegetate there. This accounts for its requiring frequent manurings, although these need not be very plentiful. When rich and abundant ameliorations are bestowed upon such land, it will become very rich in humus, and eventually be rendered exceedingly fertile; but this fertility rapidly declines if the soil is submitted to an exhausting rotation.

If it contains seventy-five parts in a hundred or more of sand, it is usually designated *oat land;* nevertheless, if we take the average of several years, we shall see that it is more proper for barley than for oats, provided it be sufficiently manured.

A soil which contains more than eighty parts in a hundred of sand, is called *sandy land;* and if the proportion of this substance does not exceed ninety, it is distinguished by the term clayey sand. Usually, so long as land does not contain more than eighty-five parts in a hundred of sand, it is comprised in the class of oat lands; nevertheless, the success of this grain is by no means certain, and it often yields little or no produce. Rye and buckwheat are the only kinds of grain which it bears with any degree of success; and if it has been sufficiently ameliorated, it is always better to sow successive crops of rye than to sow oats after rye, because the dryness to which this soil is exposed during the summer is less prejudicial to rye than to oats. Of all the plants or vegetables which are grown for the purposes of feeding cattle, potatoes have been cultivated with the greatest success on this sort of land. But the frequent plowings which, when this land is in good condition, must be bestowed upon it, in order to cleanse it from weeds, are apt to render it so loose and friable that not any of the cereals can be made to succeed on it. This is the reason that it is advisable to allow it a certain period of repose, or to lay it down to perennial pasture; and this latter is the means by which the greatest amount of advantage can be derived from it, for when sown with sheep's fescue-grass (*festuca ovina*), rye grass (*lolium perenne*), Dutch clover (*trefolium repens*), common burnet (*poterium sanguisorba*), &c. it produces a pasturage which is exceedingly well calculated for sheep, although not usually sufficiently rich for cattle. After this period of pasturage or repose, the land may be cultivated afresh, and will, if sown with rye, yield very fine crops.

The value of it decreases from twenty to ten in the ratio of one for every hundred in which the proportion of sand increases; and this diminution takes place even when the land contains from one to one and a half parts in a hundred of humus; and if, as sometimes happens, it contains a yet smaller proportion, its value is still less.

But if the land contains ninety parts in a hundred of sand, it then belongs to a still lower class, unless it is abundantly manured; nor until after a long period of repose can it be made to bear a crop of cereals with any degree of advantage, and then this crop impoverishes it very much. Land which does not contain more than ninety-four parts in a hundred of sand may, if properly managed and sown with the small varieties of the *festucas* and vernal-grass, be made to yield herbage enough to feed one sheep per acre during the period of repose. But when the soil contains a yet larger portion of sand, it will only bear grey-hair-grass (*aira canescens*), yellow goats'-beard (*tragopogon pratensis*), and some other plants which contain scarcely any nutritive juices; it then falls into the class of loose blowing sands, the surface of which it is very dangerous to break, because then the wind moves it and carries it away in whirlwinds.

It may be regarded as an invariable rule that sandy soil loses at least one part in a hundred of its value by the augmentation of a hundredth part in the proportion of sand; and when it degenerates into loose blowing sand, it possesses a mere negative value in by far the greater number of cases.

There are many kinds of sand which are not composed solely of silica, but also

contain some grains of carbonate of lime. This calcareous sand is not so insoluble as the silicious, and is much more favorable to vegetation. We do not, however, yet know any decisive experiments which bear upon this point.

The presence of lime, especially when it is intimately combined with clay, increases the fertility of the soil to a certain degree. 1. Because, when intimately and uniformily mixed with clay, it renders that substance more friable and less tenacious. Such a mixture is easily reduced to a fine powder by exposure to the air. 2. Because it facilitates the drying and aerefaction of the clay, and prevents too great an accumulation of water from taking place in it. It appears, on the other hand, to consolidate sand, increasing its cohesive attraction for water, and intimately uniting with it by means of the humus. 3. Because it favors the decomposition and reciprocal action of the nutritive juices contained in the soil, and separates those animal or vegetable substances which adhere too closely to the clay. It is as yet doubtful whether it transmits its carbonic acid to the humus or even to the plants themselves; whether, on the other hand, it absorbs it from the air, and consequently acts as a nutritive body. There are, however, various reasons to induce us to believe that such is the case. 4. Because it prevents the formation of those acids which are so easily produced in the soil; or where they already exist, it tends to neutralize them and prevent them from being injurious. 5. Because the husk of grain grown on land which contains a suitable portion of lime is much thinner, and the grain itself yields a considerably larger quantity of farina; and farther, because it is singularly favorable to all plants belonging to the class "diadelphia," and, consequently, to those which bear pods; all kinds of clover succeed wonderfully on it.

When a soil contains too great a proportion of lime, that substance is apt to become prejudicial. This is especially the case in districts where a chalky formation exists. 1. Because it does not retain moisture, and has even a greater disposition than sand to suffer it to evaporate; consequently, during warm, dry weather, it is totally parched and reduced to dust. 2. Because it consumes manure and humus very rapidly, accelerates the passage of these substances to the plants, and thus hastens their vegetation at first; and does not reserve any nutrition for their support during the latter stages of their development; on which account they fall off and perish before they arrive at maturity.

As I know not any kind of soil which contains a superabundance of lime, I shall quote a passage from one of Chaptal's works:—"Land, in which there is a preponderance of lime (M. Chaptal means carbonate of lime) is porous, light, easily permeable by water, can be tilled without difficulty, forms a paste which possesses little or no consistence, and is not sensibly altered by the action of fire. The air easily penetrates calcareous earth, and is there capable of vivifying the germs which it contains to a certain depth; but water, which penetrates it without resistance, escapes again with equal facility. Land of this nature is alternately swamped and parched; and those plants which are not strong enough to withstand such variations, languish or perish in a soil of this nature."

According to Reissert and Seitz ("Annals of Agriculture," vol. ix. p. 236), calcareous land, which is composed of forty parts in a hundred of lime, thirty-six parts of sand, and a large portion of clay, is more difficult to till when it has become very damp after a heavy fall of rain, than argillaceous land would be; but when it is dry, this difficulty is considerably diminished.

That proportion of lime in land which is most advantageous to it, is a quantity equal to that of pure clay. Of all the fifty-three varieties of soils produced by artificial combinations experimented on by Tillet, that which appeared to be most favorable to the vegetation of grain was composed of 3-8 of potter's clay, 4-8 of shell or fossil marl, and 1-8 of sand.

The more lime a soil contains, the less sand is required to correct the defects of the clay. But it is highly necessary that some portion of sand should enter into the combination; for without that substance, marl, when dry, would be too tenacious, and when moistened, too soft. General experience confirms the fact, that the proportions indicated by Tillet certainly are the best.

But even when lime is mingled with the superior layer of the soil in so small a quantity that it scarcely appears to have any influence on its consistence, it increases its fertility probably by means of the chemical action which it enters into with the humus and manure. From general experiments and observations,

which, nevertheless, cannot be very correct, it appears, that ten parts in a hundred of lime raises the value of argillaceous or clayey soils from five to ten per cent., and even higher, when the land contains a large portion of humus.

On the other hand lime is injurious, when the proportion of it contained in the soil exceeds that of the clay. When the lime is mingled with much sand, it forms a soil too dry and warm, and which, even when plentifully manured, cannot be made to yield good crops of anything but those vegetables which cannot be materially injured by drouth, as maize, &c. Chalky soils, which are principally composed of lime, are of this nature, and suffer both from drouth and humidity, becoming, in the latter case, sloughy.

When speaking of the soils in which humus forms the chief component part, and in which this substance cannot easily be exhausted, we allude to those which contain more than five parts of it in a hundred; such is only the case, however, in alluvial soils, or those which are formed by the deposit of rivers or of the sea. High grounds and mountainous districts, both those which contain a large portion of clay, and those in which sand is the preponderating ingredient, rarely possess five parts in a hundred of humus, indeed, they seldom contain more than three parts of mild humus, especially at the close of a rotation, when they almost always require fresh manuring in order to enable them to yield profitable crops. The quantity of humus contained in a soil diminishes in exact proportion with the number and condition of the crops derived from it; allowance, however, being made for the manure which it receives. This diminution is not, however, so considerable as it appears or might be expected to be; an amelioration of two hundred quintals of humus leaves, when decomposed, scarcely thirty quintals of dry humus, and this quantity has to be spread over an acre of land, the superior layer of which is generally composed of about 12,000 quintals of earth. Thus, four hundred quintals of soil receive one quintal of manure, that is to say, each hundred receives a quarter of a quintal.

The proportion in which the soil *naturally* contains this aliment of plants and vegetables is, therefore, a very important point; and it is most important that this proportion should be tolerably large, because the less humus a soil contains, the more difficult it is to create that substance in it.

The value of a soil increases in proportion with the humus which it contains. In good clay land I have generally found two parts in a hundred of humus even at the close of the rotation; or, to explain myself more clearly, a portion of the soil which has been submitted to incandescent heat, after having been deprived of its fibrous parts and of its lime, and dried at a temperature a few degrees higher than that of boiling water, has lost that portion of weight. The evaporation of water, most likely, had nothing to do with this diminution of weight, since it is more than probable that the moisture which the clay had previously lost is immediately reäbsorbed during the process of weighing.

We shall therefore consider two parts in a hundred to be the average quantity of humus contained in clayey vegetable soils, one and a half parts as the average in sandy vegetable soils, and one part as the average contained in sandy soils; and we shall take these quantities as a preliminary condition in those estimates already given of sandy and argillaceous lands. The increase of a half-hundredth part of mild humus will augment the value of the soil which contains it five per cent.; thus, land containing two parts in a hundred of humus and valued at 50, will, if it contains two and a half parts, be worth 52½, if it contains three parts in a hundred, its value will be increased to 55; and the same decrease of humus will be attended by a similar decrease in the value of the soil.

The quantity of humus which a soil contains is always taken into consideration even in the ordinary classification of land. It is well known that the same soil is sometimes made to bear barley and at others oats, according as it has been more or less frequently and abundantly manured, and its resources husbanded; thus, whether the quantity of humus has been increased or diminished by the system of cultivation pursued, a clay soil, which is placed by persons well skilled in the classification of land among oat-lands, does not usually contain more than one part in a hundred of humus. Should it contain three parts in a hundred of this substance, or more, and be otherwise exempt from defects, it then becomes second class wheat-land; this addition of humus may be bestowed upon it by cultivation, but that is not so easily done as is generally imagined.

In the first place, I here suppose the humus to be mild, free from all acidity and from all admixture of astringent substances, and consequently soluble. A soil may be very rich in sour or acid humus, and yet barely possess a particle of fertility. We have found five parts in a hundred of humus in a sandy soil of Pomerania, on which four to one of rye was regarded as a fine crop. When submitted to incandescence, it betrayed its nature by emitting an odor like that of burnt turf; and when we came to analyze it more carefully, we found that it contained a considerable portion of acidity. This humus was created by the prevalent method of manuring in that country with a substance partly composed of heath and furze. Such land might, however, be rendered fertile and made to produce beneficial effects by being dressed with an addition of marl.

Land impregnated with a thoroughly acid humus which turns blue litmus paper into a bright red, as marshy land, or soils which approach nearly to peat in their nature, is not adapted for the production of any useful vegetable or plant, and has little or no value; it may, however, be ameliorated without difficulty if there are not any adventitious circumstances to prevent it. Such land is seldom found except in bogs and marshes, or low damp situations, and is generally covered by a tenacious layer of clay. The principal point to be ascertained is, whether there be any possibility of its being drained. When this is practicable, the best method of effecting an amelioration is to pare and burn it. In this operation, one portion of the acid is consumed by the fire and the remainder neutralized by the potassa which the ashes contain, and by this means the land is not unfrequently converted into rich wheat land.

Land which is impregnated with humus resulting from heath or furze, and which is commonly called heath land, produces nothing but furze and plants of a similar nature so long as it remains in its natural state; but it may be rendered fertile by means of paring and burning, by manure, by lime and marl, and by continuous irrigations; the value of it then depends upon the nature of the earths of which it is composed. Sometimes such lands are naturally very good, and their want of fertility is occasioned solely by the plants with which they are overrun, and which themselves prepare the juices which are required for their nutrition. In this case, if the plants are destroyed and those defects are corrected in the humus which render it unfit for the production of useful plants, the land may eventually be rendered exceedingly fertile. The lime and marl which is generally found under the layer of heathy mould, are very efficient auxiliaries. Land of this nature must be valued according to the greater or less difficulties which oppose themselves to the extirpation of the furze and the amelioration of the soil; but where this cannot be effected at all, or at any rate not without great trouble and inconvenience, it cannot be estimated at more than 1.

In this case, however, as well as in others in which it is requisite to make a valuation in order to value the interests of different persons, it must, in my opinion, be considered as a rule, that the soil should only be valued according to its actual state, because those ameliorations which it may be possible to effect in it can only be compassed by industry, intelligence, skill, and the expenditure of some capital; and those who attempt to calculate the expense or trouble of such ameliorations and improvements beforehand, and the probability which exists of their being attended with success, must invariably fall into errors.

So far as my own experience goes, or the experiments and researches of others lead me to believe, the fertility and quality of those soils which we have analyzed, and their value, may be calculated with precision upon the principles we have laid down, supposing, in the first place, that they are situated in places adapted to their nature, as, for example, light land, rich in humus, on a plain or flat surface, as indeed is generally the case.

If we frequently compare the composition of soils that have been carefully analyzed with such of their external properties as are evident to our senses, we shall, by degrees, acquire the faculty of discovering the nature of this composition simply by attending to their exterior characteristics. Next to color, the most positive indications of the presence of humus are, a certain lightness of the soil, a characteristic mouldy smell, and the white shoots of the *lichen humosus*. Clay betrays itself by its tenacity and unctuousness. Sand is distinguished by its harshness when rubbed between the fingers, and with still greater certainty by examining the broken and crumbled pieces with a microscope of moderate

power; this method is found very useful in determining the quantity of sand which one soil contains more than another, and in distinguishing "black humus." The usual mode of ascertaining the presence of lime in a soil is by pouring acids upon it and observing whether any effervescence takes place; and the degree of the effervescence is taken as an indication of the quantity of lime which the soil contains, at least until there is time and opportunity to submit it to a more definite analysis.

The soil is indebted for its consistence or cohesion as well to the properties as to the proportion of that earth which forms the predominating ingredient. The explanations which we have to offer on this head will be limited to describing the technical terms by which the degrees of consistence are designated.

Land which, when rather too damp, clings to the plow or harrow in the form of a glutinous paste, which cannot be removed without difficulty, and the detached portions of which form coherent masses, is termed "hard tenacious" or "intractable;" such land cannot be easily divided or penetrated excepting by a sharp or pointed instrument, and the incisions made in it present a smooth and shining surface. When dry, it hardens to the density and brittleness of a tile; and the clods, when broken by actual blows, divide into shapeless and lamellated fragments; and it not unfrequently happens that it is impossible to pulverize it at all. When the sun strikes powerfully on such a soil after it has been soaked by heavy rains, the surface becomes indurated and baked hard, while beneath this crust it still retains its humidity; it is then said to be close and compact, and that a crust is formed over its surface; it then contains more than eighty parts in a hundred of clay.

Land is said to be "stiff," "strong," and "heavy," when, being dry, it may be divided with less difficulty, and breaks into pieces which have a *malt*-like and granulous appearance. Such land can seldom be pulverized either by the plow or spade; those instruments only reduce it to clods which cannot be broken and thoroughly divided except by repeated harrowings; it usually contains more than fifty parts in a hundred of clay.

A soil is said to be "light" and "free" when it forms itself into clods on becoming moistened; but when the clods can be readily divided and pulverized by a slight degree of attrition or pressure, in this case it generally contains from twenty to forty parts in a hundred of clay.

A soil is termed "movable" or "blowing," when its dry particles have little or no consistence or cohesion, but fall to powder without forming clods. To this species belong all those soils which contain more than ninety parts in a hundred of sand, chalky soils, and those which contain a large portion of humus and but little clay. When the soil is so loose that the wind can easily raise and scatter it about, it is then termed "pulverulent."

The tenacity and degree of cohesion existing between the parts of a soil can be best ascertained by examining it eight and forty hours after a gentle rain. Those who are accustomed to observation can ascertain all they wish to know upon this point by merely driving a stick into the soil, and sometimes even by simply pressing the foot upon it.

In forming an estimate of the value of a soil, an examination of its depth should follow immediately after the examination of its constituent parts. By the depth of soil, I mean the thickness of the layer of earth which forms its surface, the layer which is usually termed vegetable earth, and which is homogeneous and equally impregnated with humus throughout its whole extent. In most land it descends very little below the depth of that layer which has been recently moved by the plow: when a section is cut vertically, the line of demarkation between the vegetable earth and the subsoil is very apparent. Sometimes this layer is not more than three inches deep; but the usual depth is about six inches; and it sometimes extends ten or twelve inches below the surface. It is only in those places where the soil has been amassed and deposited by the action of water, or where an extraordinary system of cultivation has been carried on, that we find the soil equally impregnated with humus to the depth of one, two, or three feet: six inches may, we think, be regarded as the average depth of the soil; we shall, therefore, consider that in order to be exempt from defects, and to be equal to the value which an investigation of its constituent parts leads us to give it, a soil must possess this depth of thickness.

A deep soil contains a larger portion of vegetable earth and of that succulency so necessary to the nutrition of vegetables; and even if this excess of vegetable mould should not be useful to all plants, it agrees with some of them, even when the whole depth of the soil is not turned up. And, besides, this thickness of the superior layer of his land enables a skillful husbandman to draw at will upon the riches which it contains, and occasionally, or about once in six or seven years, to turn it all up and profit by the stores of succulency and nutrition which the under part of it will yield. The roots of all plants sown in a soil of this nature, even those of the tribe of cereals penetrate in a right line, and seek that nutriment at a greater depth, which they would otherwise have had to extend themselves laterally in order to obtain, and they may, therefore, be sown much thicker without causing any detriment to the crop. A deep soil will, therefore, yield much larger crops than a shallow one, provided its nature is similar, and that it is equal in all other respects. The roots of corn are not, as some persons assert, never more than six inches in length: I have seen them exceed twelve inches where the soil was deep enough to admit of such an extension. The roots of vegetables and clover penetrate much deeper in a right line; the same may also be observed with respect to lucerne, and root crops; land, therefore, in which the layer of vegetable mould is very thick, is peculiarly favorable to the cultivation of these crops. Besides, such land evidently possesses one very great advantage, namely, that of suffering less from humidity and drouth. The water which falls upon it has more room to penetrate before it encounters the under-stratum. Argillaceous land, which is tolerably deep, can only be properly drained by means of subterraneous trenches. But as a deep soil can absorb and contain more water in its pores, it can also retain it longer, and returns it to the surface from its subterraneous reservoirs when it is required. These soils are peculiarly characterized by their resistance of humidity and drouth; and all attentive observers must have remarked that cereals growing in a deep soil are less liable to be laid or lodged even when the ears are very large and that where this misfortune has been occasioned by hail, tempests, or heavy rains, the corn frequently has sufficient strength to raise itself again.

On shallow land, exactly the contrary effect takes place. These soils are of two kinds: those which are not of a nature to admit being dug more deeply, and those in which, during the process of cultivation, the layer may either be augmented by digging, or by penetrating lower, gradually and successively with the plow. We shall consider this circumstance again when we come to treat of the inferior layers of the soil.

Soils which have no bottom, or in which the layer of vegetable mould is so thick that it is scarcely possible to reach the bottom of it either by plowing or by digging it up with the spade, present the possibility of preserving the fertility of a soil without the addition of manure;* the fertility may be equally kept up either by thoroughly digging and raising the soil, or by excavating successively from place to place, and spreading those portions of earth over the surface which have been derived from the interior parts. Such soils are, therefore, of an almost incredible value..

But in what proportion does the greater or less depth of a soil increase its value? We have already supposed six inches to be the average depth which a soil ought to possess in order to be exempt from defects on that point, and we are quite convinced that every inch added to the depth of land increases its value eight per cent.; so that a soil, where the vegetable layer is twelve inches thick, is worth half as much more as that in which it is only six inches. We are not, however, prepared to say that the value increases in equal proportion when the depth is yet farther increased and becomes so great as to render it scarcely possible to reach it by means of simple plowings; but as the vegetable earth which is beneath the layer turned up with the plow cannot fail to be beneficial to plants, we shall not hesitate to affirm that every additional inch of depth beyond yond twelve adds five per cent. to the value of the soil.

On the other hand, we should advise that in general the same proportion should be observed in decreasing the value according as the upper stratum of earth diminishes below six inches, which we consider to be the average.

* At least, until the whole of this vegetable layer has been turned up, brought to the surface, and exhausted.

If, therefore, a soil of	6	inches thick is worth	50
That which is	7	inches thick is worth	54
That which is	8	inches thick is worth	58
That which is	9	inches thick is worth	62
That which is	10	inches thick is worth	66
That which is	11	inches thick is worth	70
That which is	12	inches thick is worth	74
That which is	5	inches thick is worth	46
That which is	4	inches thick is worth	42
That which is	3	inches thick is worth	38

There is no doubt that a soil might acquire this increase of value by means of the artificial deepening or thickening of the layer of vegetable earth. With regard to the expenses with which such an operation would be attended, they vary greatly; at one time exceeding, and at another falling below the value of the increase of depth.

That layer which is situated below the vegetable soil is called the subsoil, under-stratum, or virgin earth. This layer is either composed of the same elements as the superior portion, with the exception, however, of the humus and those matters which are derived from the atmosphere, or it is composed of substances of a wholly different nature. The nature of the subsoil has a considerable influence upon the quality of the upper or superior layer; and the more shallow the vegetable soil, the greater is this influence. The under-stratum which is found beneath clayey or argillaceous land, is usually of the same nature; but is distinguished from the vegetable soil by its crudity, tenacity, and impenetrability. But the same kind of subsoil is not unfrequently found beneath sandy soils in a flat but slightly inclined position; an inferior layer of this nature may tend greatly to ameliorate such land, by preventing the water from settling and saturating the soil with moisture. A portion of this subsoil may occasionally be brought to the surface either by plowing or digging, and mingled in suitable proportions with the sand. This mixture often appears at first to decrease the value of the soil; but afterwards, when it has been brought more fully into action, the land is found to be sensibly ameliorated.

But when the substratum of an argillaceous soil is rough and uneven, so that the moisture cannot drain off in a uniform manner, and settles and becomes stagnated, it is as likely to become too damp in rainy weather as the more sandy soils.

The subsoil is occasionally found to be of a marly or calcareous nature even in those places where the superior layer of earth does not appear to contain a particle of lime. Here the deepening of the soil by means of plowing, or of thorough and repeated diggings, produces surprising effects, and ameliorates it in a sensible and double manner; because the marly clay, however tenacious it may appear to be while it forms a portion of the under-stratum, is no sooner brought to the surface and thrown into contact with the atmosphere than it divides and becomes so completely pulverized as to be easily mixed with the soil. Such land is, therefore, susceptible of very great improvement.

A layer of sandy earth is also frequently found beneath an argillaceous or clayey vegetable soil, which, if it is not placed too near the surface, nor at too great a depth beneath it—that is to say, when it is not more or less than a foot or a foot and a half below the surface, and the layer of it is sufficiently thick—produces a peculiarly fertilizing effect upon the soil, rendering it at once warm and solid; absorbing or suffering all the superfluous moisture to run off, and preventing it from ever suffering from an excess of humidity.

Land in which the vegetable soil is shallow above the sand, which constitutes the under-stratum, can bear little or no sun, and is very much exposed to the effects of drouth; although it appears to be and is very fertile during a damp temperature, or in spring, while it yet retains the moisture which it has imbibed during the winter months.

Sometimes the layer of sand or gravel is very fine, and situated beneath a layer of impermeable clay. In this case, if the land is perfectly flat, and without any slope or declivity, the water is amassed in this layer of sand as in a reservoir, can find no outlet, and therefore ebbs back to the surface, which it soaks, forms into bog and moist or damp places; such land becomes cold and sterile, because the water in its progress carries with it all those particles of dissolved dung or

manure which were not intimately combined with the soil, and deposits them in the layer of sand beneath. This is one of the very worst of all the varieties of soils, and can only be ameliorated by means of complete drainings; by such a process it may eventually be rendered perfectly healthy.

The looser and more porous the subsoil of sand which lies beneath a sandy soil, the drier will that soil be. If after a certain depth the sand possess a certain degree of consistence or cohesion, and the flow of the moisture is thus partially arrested, the soil will be found to be fresher.

Sometimes the under-stratum is composed of rocks or stones, and is then covered with a bed of vegetable earth of greater or less thickness. This latter is often only a few inches thick, as is particularly the case in mountainous districts.

Of all subsoils which are composed of stone, those formed of limestone are the best and most beneficial. At the surface this stone is often rough and harsh to the touch, coarse-grained, and full of clefts; it absorbs water, and is not impenetrable to the roots of plants growing in the soil above it. There are some vegetables which appear to attack the stone itself, and can derive a portion of their nutriment from the carbonic acid which it contains; this is particularly the case with sainfoin, and most of those plants which belong to the class diadelphia, and also trees and shrubs; so that calcareous and gypseous rocks are less sterile than others.

Argillaceous schists, covered with a thin layer of vegetable earth, become unloosened when broken by the plow; and the superior layer is thus rendered deeper, and, at the same time, ameliorated. Granite excludes all hope of vegetation; a thin vegetable soil reposing on an under-stratum of this nature will never improve of itself, and can only be ameliorated by additions of manure and of mould.

Sometimes the subsoil is composed of gravel or round pebbles; in this case it is only necessary to ascertain whether they are sufficiently covered with vegetable mould, or whether the superior layer of the soil is too shallow. Under the former circumstances they are not injurious, but rather have a contrary effect; where the soil is of an argillaceous nature they are exceedingly useful by the facility which they afford to the percolation of the superabundant moisture.—We shall hereafter speak of those pebbles and stones which are mixed with and lie near the surface of the soil.

Ochre, or steel ore, which is often found below the surface of the soil, is extremely prejudicial to vegetation; and when not covered by a layer of earth sufficiently thick to prevent the roots of the plants from reaching it, may be said to poison it. It is usually covered by a blackish bed of earth, of a brownish hue, and of the same nature as itself: this layer becomes harder the farther we penetrate into it; and at last is found to be compact as a stone. Trees perish as soon as their roots touch this earth.

With regard to humidity, we shall divide the subsoils into the free or porous, and the close or retentive. The former species is sandy, and frequently stony, and rarely without clefts or openings through which the water can percolate.—The less sand this layer contains, the more impermeable does it become; however, it not unfrequently happens that we find clay which contains a great deal of sand to be wholly impermeable as soon as it becomes hard. Thus, when it is always plowed to an equal depth, the pressure of the sole of the plow and the tread of the horses gradually forms a hard crust, which is brittle and impermeable to water;* while the soil above and below is loose and permeable.

In by far the greater number of cases, we find that the too great humidity of a soil is entirely caused by the impermeability of the under stratum; for, although the superior layer may be more or less retentive of moisture, or naturally more or less liable to suffer from damp or drouth, this does not appear to be injurious to vegetation; at any rate, so long as no more moisture is contained in the soil than the earths of which it is composed can take up and absorb by means of their cohesive attraction for water. But where the moisture cannot evaporate or drain away, but soaks and saturates the land, rendering it like a thick paste, there is scarcely any plant we cultivate which would not be injured by such an excess of humidity. When the sub-stratum is impermeable, and, instead of forming a kind of inclined plane, and thus affording a channel for the water to

* The moorband pan of the English farmers.

drain away, is uneven and full of furrows, the water settles as in basins or reservoirs; and the land can only be dried and rendered healthy by means of evaporation, or of artificial draining. Those springs which rise in some soils are usually created by the nature of the sub-strata.

This excess of humidity may also be produced by water which runs from the surface of higher grounds, and, finding no ulterior outlet, settles and injures the land. And, lastly, it is occasionally caused by the overflowing of neighboring rivers and lakes.

We shall enter more fully into this subject when we come to speak of draining and the drying of land; and shall only allude to it here on account of the influence which the greater or less difficulty there is in overcoming and obviating this defect has on the land. Sometimes humidity renders land unfit for almost every purpose; at others it is highly favorable to the vegetation of herbage, and renders the soil peculiarly well adapted for meadow and pasture land; but it never gives it those qualities which fit it for the cultivation of corn. Occasionally, it admits of spring corn, and especially oats, being sown; but never autumnal corn.

The spring is the best time to form a correct estimate of the injurious effects of the moisture with which the soil is impregnated. Traces of it are evident enough in the plants which vegetate there at all seasons; but they are more equivocal. The best time to form a judgment of the disposition of a soil to retain moisture is some few days after a gentle rain; it is then termed—

(*a*). Very dry, when on being squeezed in the hand it does not afford the slightest trace of moisture.

(*b*). Dry, when it only betrays moisture on being forcibly squeezed.

(*c*). Fresh, when its moisture is easily apparent.

(*d*). Humid, when it moistens the hand on being slightly compressed.

(*e*). Wet, when on being squeezed the water oozes out by drops; and when a clod of earth turned up with the spade, or a furrow made by the plow, glistens with moisture.

(*f*). *Aqueous* or *marshy*, when the water stands on the surface, or rises into those hollows which are indented by the pressure of the foot.

By the temperature of a soil, or what is termed its *warmth* or *frigidity*, we do not mean that degree of heat which is communicated to it from the atmosphere, or by the solar rays, and which is dependent on climate and situation, but merely that which is inherent in the soil itself.

Our globe appears to contain within itself a certain degree of caloric. In fact, at the depth of ten feet below the surface of the soil, the temperature always remains equal to seven degrees of Reaumer's thermometer. This heat was, for a considerable period, thought to be produced by some central fire contained in the bowels of the earth; or, at any rate, by some great amount of caloric which has existed there from the time of the creation, and which, as it approaches the centre of the globe, becomes gradually more and more intense. But this opinion has been proved to be totally without foundation by the fact that, however deeply we penetrate during the process of mining, no increase of temperature has yet been discovered.*

* This remark appears hardly to accord with more recent geological observations:

"The first investigation of importance that presents itself," says a writer in the *Polytechnic Review*, "is the thickness of the crust on which we dwell. We have seen by the theory that this ought to be continually increasing, though with increasing slowness, and that there was a time when it was so thin as to be almost in a state of fusion. We have stated that the increase of temperature observed is about one degree Fahr. for every fifteen yards of descent. In all probability, however, the increase will yet be found to be in geometrical progression, as investigation is extended; in which case the present crust will be much thinner than we have calculated it to be; and should this be found to be correct, the ingenious theory will become a subject of more importance, in a geological point of view, than we are at present disposed to consider it. Taking, then, as correct the present observed rate of increase, the temperature would be as follows:

Water will boil at the depth of 2,430 yards.
Lead melts at the depth of 8,400 yards.
There is red heat at the depth of 7 miles.
Gold melts at 21 miles.
Cast iron at 74 miles.
Soft iron at 97 miles.

And, at the depth of 100 miles, there is a temperature equal to the greatest artificial heat yet observed—a temperature capable of fusing platina, porcelain, and indeed every refractory substance we are acquainted with. These temperatures are calculated from Gyton Movern's corrected scale of Wedgewood's pyrometer; and, if we adopt them, we find that the earth is fluid at the depth of 100 miles, and little more than the soil on which we tread is fit for the habitation of organized beings."

At the depth of 1,200 feet below the surface of the soil, the heat is always the same; it is only in some mines in Hungary where any elevation of temperature has been perceived: but this circumstance may be attributable to local causes, such as the elevated temperature of some springs, or the peculiar nature of the surface of the ground which they flow over. The caloric resulting from these subterraneous furnaces is a phenomenon that seldom occurs.

The differences or variations in the temperature of the soil are often distinguished from one another by the greater or less period which snow laying on them takes to melt, and by the greater disposition which some places have to freeze than others, independent of their position: this cannot fail to have considerable influence upon the autumnal and spring plowings. Some observations have lately been made on this subject with the help of a thermometer, but they have neither been sufficiently definite nor repeated often enough for me to be able to assert anything more positive on the subject than the following remarks upon the causes of these variations of temperature.

The temperature of a soil, in the first place, evidently depends upon its humidity. Damp, wet land is generally cold; it dries very slowly, freezes rapidly, and takes a long time in acquiring the amount of heat necessary to support vegetation: it is, on this account, designated by the terms *moist*, and *cold;* dry soils are termed *warm*, and those which are very dry are called *burning*. There is no doubt that this arises from the water absorbing a considerable portion of the caloric contained in the soil during the process of evaporation. Occasionally, however, it happens that we find sensible differences existing between the relative temperatures of soils which possess an equal degree of humidity. Land which contains a considerable portion of mould, or manure which has not been exhausted, or other substances in a state of putrefaction, is much warmer, and melts snow which falls upon it much sooner than would be the case under other circumstances, so that country people are accustomed to say that such land *devours the snow*. There can be no doubt that this heat arises from the chemical decompositions which are going on in the soil, and in the process of which a considerable degree of caloric is almost always evolved; and it is evidently by no means a figure of speech to say that manure warms the land. It acts upon it mechanically by rendering the soil lighter, looser, and therefore drier; and chemically by decomposing it.

Calcareous soils are always warmer than others, because they accelerate those chemical decompositions, and because they not only act more powerfully and promptly upon the manure and humus, but these latter, in their turn, act upon the soil. All soils are not equally good conductors of the heat which they receive externally; sand, when not too much saturated with moisture, is a better conductor than clay. Thus, a sudden change of temperature affects plants vegetating on a sandy soil much more than those which are growing on argillaceous land; and this is the reason that night frosts, and especially white frosts, are more injurious to the former than they are to the latter; probably some of the subsoils communicate that caloric which is engendered in or exists in the land, to the bodies with which they come in contact, much sooner than others do, and thus counteract the frosts, and prevent them from penetrating very deeply.

The degrees of temperature possessed by the soil are designated by the following terms:—

(*a*). Burning.	(*c*). Warm.
(*b*). Hot.	(*d*). Cold.

The value and qualities of a soil do not depend solely upon its composition and the nature of its constituent parts, but are also influenced by its *position, form,* and *situation*, and by the *nature of the surrounding localities;* all of which circumstances tend to modify its worth and utility.

The *form of the surface*—the fact of its being hilly or flat, horizontal or inclined, tends to increase, or detract from the value of land, according to the proportions of elementary earths of which it is composed.

Loose, dry, sandy soils, are most fertile when they are flat, and when they are situated lower than the surrounding country. In this position they retain moisture for a considerable period, and yet rarely possess a superabundance of it. On the other hand, such a soil decreases in value when situated on declivities, hills, or on the sides of mountains: in these situations its moisture rapidly drains away,

and is not only thus lost, but is also caught along with the fertilizing particles of mould or humus, and blown away by the wind. In such a position, a sandy soil, which, if situated on a plain, might have been cultivated with success, is scarcely worth the labor attendant on sowing it; and it not unfrequently happens that it is dangerous to break up the superior layer of such land, if we would not have the neighboring country inundated with whirlwinds of sand.

An argillaceous soil, the substratum of which is impermeable, will be improved by being situated in an inclined or mountainous situation, because the superabundant water is enabled to run off. In such a situation, all the inconveniences attendant on an excess of humidity may be obviated by means of judiciously disposed furrows and trenches: nevertheless, stiff clayey declivities are never desirable on account of the difficulty attendant on their cultivation.

The proportion in which the soil is elevated above the level of the sea has considerable influence on the climate and atmospheric temperature. Even under the same degree of latitude, the heat is always greater on plains and flat surfaces than on mountains: there is no place, until we reach the torrid zone, where the tops of the highest mountains are not covered with perpetual ice and snow. The nearer we approach the equator, however, the more do we find this ice and snow confined to the summits, but it extends lower and lower as we come nearer the polar circle. Vegetation likewise diminishes in exact proportion with the heat: those trees and vegetables which grow on high mountains are always stunted; if we ascend higher still, we find only firs and alpine plants; and as we approach the top, only a few mountainous plants are here and there visible; and finally, all traces of vegetation disappear.

A sensible diminution in the vegetation of cereals is perceptible at very inconsiderable elevations, even when the position is otherwise advantageous; provided, however, that the soil is calculated for it, wheat always thrives better than rye on hilly or mountainous situations, and oats better than barley. There is seldom any want of humidity on mountainous lands, for they are usually depots for the reception of the moisture which is contained in the atmosphere; and this is one great reason that cereals do not thrive so well here as on flat soils, warm, dry land being always more favorable to them than that which is cold and damp. But as there is generally a sufficient degree of declivity to allow of water running off, it is always practicable to drain the land by digging furrows to carry away the superabundant fluid.

One circumstance which militates considerably against the value of land situated on mountains, hills, and declivities, is the difficulty of carrying manure to it. Some persons have considered that this objection might be obviated by grazing with cattle, but the difficulties attendant on the operation of plowing would thus be considerably increased. Lastly, heavy rains and torrents often carry away with them the whole, or, at any rate, the greater part, of the vegetable soil from hills and declivities. It is, therefore, generally advisable to allow all land thus situated, however capable it may be of producing rich harvests, to be planted, or to remain as forest or woodland.

On the declivities of mountains and hills, as well as on slightly inclined plains, the direction of the inclination is a very important point.

It is a very difficult matter to dry and warm land which looks to the North. Those vegetables and animal substances which afford nutrition to plants are not decomposed without great difficulty, and are much longer in attaining the requisite degree of fermentation. Neither does the period of vegetation last so long: it commences much later, and finishes much earlier. The plants feel the want of light and heat; they are less savory, yield less fruit, and frequently suffer materially from cold winds and frosts.

Land which has a southern exposure is more easily warmed; it enjoys a greater degree of light: vegetation commences much earlier there, and attains a far greater perfection. On the other hand, such land is much more liable to suffer from drouth, and is much more exposed to the pernicious effects of those storms of hail and rain which come from this quarter.

Land which inclines toward the east is very easily drained; the atmosphere deposits less humidity on it. The morning sun calls forth all the powers of vegetation much earlier, and brings into action all those matters which have been absorbed and have lain dormant through the night. The crops sown in

these situations rapidly progress and arrive at perfect maturity; but it cannot be denied that they are very liable to be destroyed by cold nights and white frosts. These last-mentioned evils are, however, less injurious in these situations than they would be elsewhere; because the morning sun touches them sooner, although, from possessing less power at that time, it does not cause so rapid an evaporation of the dew.*

In land that inclines towards the west, the vegetation does not receive its light and heat immediately from the sun until all the night-dews and moisture have been evaporated, and those vital powers which were reänimated by rest have again become weakened; the products, therefore, which grow in this situation, are not usually very forward, and never attain so high a degree of perfection as those which receive the rays of the morning sun. Westerly winds generally convey a considerable portion of wet and moisture: therefore, land which inclines in this direction is less liable to suffer from drouth. A slight inclination towards the south of the west is a much more advantageous position. The evils occasioned by sudden thaws are most sensibly felt in these situations, because the sun does not reach the plants until it has attained its utmost altitude and its rays possess the greatest power.

The advantages and disadvantages of these various positions are considerably influenced by the composition of the soil and its other properties. Cold, damp, argillaceous land is improved by exposure to the east and to the south; and very much deteriorated in value when it faces the north or west. Sandy or calcareous soils, on the contrary, are improved by being inclined towards the west, as are all dry, warm soils; and are proportionally deteriorated by facing the south or the south-east. An inclination toward the north can never be advantageous, especially when the declivity is so abrupt that the sun's rays only reach it in an oblique direction.

It occasionally happens that land is deprived of light, and the rays of the sun are prevented from reaching it, by the intervention of surrounding objects, as forests, mountains, large trees, or buildings. Now, leaving the heat imparted by the rays of the sun wholly out of the question, the light is in itself indispensable to the welfare of plants, and is, in all probability, an active agent in accelerating certain decompositions which are constantly going on in the soil.

We know that all plants seek the light, and invariably turn in that direction from which they can derive the greatest portion of it. This is quite evident in those growing in the open air, but still more so in rooms and confined spaces; and it may be still farther tested by enclosing vegetables in wooden boxes, into which light is only admitted through a cleft in the wood; the strength and eagerness with which these plants force themselves into the clefts in search of that invaluable aliment to them, light, is almost incredible. In thick plantations, whether of trees or vegetables, the whole force of the vegetation is pushed upwards, and each one seems to vie with the other which shall obtain most light.

There is not the least doubt that vegetation is always higher in thick plantations, but at the same time the lower parts are weakened by this rapid growth. All plants that grow in obscurity or in shady places, have a dull, sickly look; their tissue is weak and colorless; their shoots long, thin, flabby, and easily broken; they have not their proper flavor, and their juices are insipid and watery. On the other hand, the more intensely and vertically the rays of light fall upon plants, the stronger do these latter become, and the more perfect and vigorous are all their parts. The green hue of the leaves is produced solely by the action of light; and this accounts for those which are not fully developed, or only just bursting, being pale and colorless. Various experiments tend to prove that this particular effect of light is totally independent of the heat which is transmitted at the same time by the rays of the sun; a strong artificial light has been found advantageously to replace sun-light, provided that the temperature is otherwise the same.

It cannot be denied that plants germinate in land which is overshadowed; indeed, a sheltered position is rather favorable than otherwise to their germination; but in such cases they only attain a partial degree of development, do not

* In the country in which I reside, it has been remarked that those portions of land which receive the first rays of the morning sun are more apt to suffer from the effects of white frosts than others, because the sudden transition from cold to heat sensibly affects delicate plants. [French Trans.

yield much nutritive matter, and their fruit seldom reaches maturity. Grass which grows under trees the branches of which meet together affords little nourishment to cattle.

The nature and composition of a soil can alone enable us to decide whether it is most advantageous for it to be exposed to the action of all the winds of heaven, or sheltered by hills, mountains, forests, buildings, or hedges. Damp, argillaceous soils are much more benefited by exposure to the open air than by being sheltered from the action of the wind. Where they are in a sheltered position, the snow does not melt so soon, and the land takes much longer time in drying, especially in the spring. On the other hand, dry, sandy, warm soils are often materially benefited by being sheltered from the wind, and may often be considerably improved by being surrounded with hedges, or protected by a plantation of trees on that side whence the wind the effect of which would be most prejudicial may be expected to blow. Wind is, in general, very injurious to land of this nature, drying up all the moisture which it contains, and scattering abroad the upper layer of earth and the humus which is mingled with it, and laying the roots of all the plants in one place quite bare, while in another it buries the whole of the vegetation under a cloud of rough sand.

With regard to the plants themselves, wind acts differently on different kinds. In some it facilitates the fructification, while in others it tends to oppose it; the latter, therefore, seldom yield much seed unless they are planted in sheltered spots.

Lastly, it is also necessary to take into consideration the nature of the atmosphere and temperature which constitute what we term a climate. If this climate is such as the latitude would lead us to expect, and the average temperature of the atmosphere is suitable to it, there is no need of our inquiring farther into this circumstance, all things then being in their natural state.

But the numerous modifications in the state of the atmosphere and of the temperature which are observable in some districts and in isolated portions of land, render it absolutely necessary that we should enter more fully into this subject than we have hitherto done.

The different degrees of warmth or heat of which we are sensible are not solely attributable to the solar rays, or to their direction being more or less vertical; there are many other circumstances which appear to tend, in a greater or less degree, to produce these effects. The decomposition which is constantly going on in the atmosphere; the influence of exhalations which emanate from the surface of the earth; that interchange of temperature between neighboring lands which is effected by means of the currents of air; the number, size, and extent of the mountains or forests which environ or intersect a country, and protect it against the cold, or refresh it by means of their frozen summits; the relative hight of a country; the proximity of the sea or of large rivers or lakes; a sandy or a marshy soil—all these are circumstances which deserve consideration, as tending to exercise considerable influence on the local temperature.

That fluid which is suspended in a state of aeriform solution in the atmosphere, is precipitated much more abundantly in some places than in others. As yet, we have not any accurate meteorological observations or exact data with respect to the quantity of rain which has fallen in different districts or countries; nevertheless, such observations always must be peculiarly interesting to an agriculturist.

We have already stated that the summits of mountains have a far greater tendency than plains or flat surfaces to attract the fluid contained in the atmosphere. Independent of this consideration, the attraction of the aqueous vapors is far greater in some places than it is in others; they precipitate themselves in the form of heavy dew, fogs or rain. Those districts which are situated near the sea or to lakes, or even to large rivers, receive a larger quantity of vaporized water, and are in general much damper than others; especially if these lakes or rivers are situated to the west of the land. This circumstance frequently tends to ameliorate dry soils, rendering them adapted for the growth of herbage; but it detracts in no trifling degree from the value of such land as was previously inclined to humidity.

Those vapors which are exhaled from standing pools of stagnant water, and especially those given out by marshes, often possess very deleterious properties;

the fogs which they engender frequently empoison whole plains so completely, that every year the cereals grown on them are attacked by various diseases, and yield but a scanty produce in grain, although the crop may have looked well and healthy in the spring. It is quite evident that the evil arises from this cause, because after the land has been thoroughly drained, the crops will always be found to thrive.

Extensive forests of lofty trees also appear to attract moisture, or, in other words, to condense the water which is held in a state of aeriform solution by the atmosphere; in fact, it has been generally remarked that a larger quantity of rain falls in well-wooded districts than in others.

Lastly, there are countries in which the clouds gather much more than in others. This has been attributed to their sometimes following the course of rivers, at others gathering over neighboring hights, or receiving their direction from chains of mountains. Some countries almost always receive the brunt of those storms which have risen in certain quarters; while others seldom or never suffer from them, or at any rate sustain very slight attacks. As storms of rain are in general rather beneficial than otherwise, the former places are distinguished by their fertility, although at the same time they are more exposed to the devastations occasionally produced by hail.

The atmosphere generally, and the inferior strata in particular, do not contain water alone, but various other substances which have considerable influence on vegetation, and these substances enter into its composition in various proportions. It is well known that carbonic acid gas, as well as carbonated hydrogen, sulphuric and phosphoric gases, are exceedingly favorable to vegetation, and contribute materially towards the improvement of the soil. But it is probable that the atmosphere also contains other and more compound substances, especially emanations from partially decomposed animal bodies. Extremely populous countries, in which a great number of cattle are kept and an immense quantity of provisions consumed, and in which numerous decompositions are constantly in operation, and the emanations from which combine with the atmosphere, are peculiarly remarkable for their fertility; and numerous observations seem to prove that this extraordinary fertility is totally independent of the extra amount of manure which can be applied to the land in these countries.

In large towns and their environs, this influence of the atmosphere on the fertility of even the worst kinds of land, cannot be mistaken. Those observations which were made in the preceding section on the vapors which emanate from stagnant water, prove that the atmosphere is capable of containing deleterious as well as beneficial matters. Incontrovertible experiments have demonstrated the pernicious influence of the barberry on all kinds of cereals growing near it.

The value of a soil may be considerably modified by the greater or less quantity of weeds that it contains; I say the greater or less quantity, because we seldom or never find a soil entirely exempt from this defect.

All those plants which vegetate in any spot where it is not desirable that they should exist, are termed weeds, because they injure the crops which are cultivated there, by usurping their place, and depriving them of a portion of that aliment which was destined for them, and by accelerating the exhaustion of the soil. We shall, however, here confine ourselves to those kinds of weeds which so completely choke the soil with their roots and seeds as to render it impossible to get rid of them without great labor, difficulty, and considerable sacrifice; and which exercise an evidently prejudicial influence on the success of the crops.

1. Those which propagate themselves solely by means of their seeds.
2. Those which are multiplied by means of the suckers from their roots.
3. Those which are re-produced by one or both of these means.

Those weeds which are re-produced by means of their seeds may be divided into two classes: the *annuals*, or those which spring up, produce, and shed their seed in the same summer, and then perish; and the *biennials*, which spring up the first year, live through the winter, and produce their seed in the second year of their vegetation. Neither of these two classes possess long-lived roots; the whole plant perishes as soon as the seed has reached maturity.

The seeds of weeds appertaining to the classes of which we are now speaking are of such a nature as only to germinate when very near the surface of the soil, where the atmosphere can act upon them. When situated at a greater depth,

or enclosed in clods of earth, they do not germinate, but remain healthy, and preserve all their vitality until brought into a position which is favorable to their development. There does not appear to be any limit to the period during which this seed can preserve its vitality; for when we come to plow up land that has remained uncultivated for an unknown period of time, and in which no traces of weeds had ever been observable, it suddenly becomes covered with them. Thus, in the marshes of Oder, an amazing quantity of wild mustard (*sinapis arvensis*) will shoot up, when some portion of land which the oldest person cannot recollect having been any thing but a marsh is plowed up, and the turf thoroughly destroyed and divided. The seed whence this plant is produced must have been brought there at some remote period, and deposited in the mud by the action of water. It has often been observed that weeds of this nature spring up in earth that has been dug from several feet below the surface of the soil, and even from the ground which formerly constituted ancient forests. A blackish earth was found beneath an old building, which certainly had existed for upwards of two hundred years, and was transported to a garden to mend the soil; a quantity of *chrysanthemum segetum* (corn marigold) sprang up, although this weed had never before been seen in that place. The frequent recurrence of these and similar phenomena has led many persons to believe that these plants were spontaneously produced by Nature without the introduction of either seed or germ, as if it were possible that there could be a single exception to the universal rule, "*omne vivum ex ovo.*"

The immense number of minute seeds that can exist in a soil is beyond all comprehension. When a portion of land is carefully divided and reduced to powder, it speedily becomes covered with a thick bed of weeds, which is easily destroyed by the action of the plow; but the second portion of earth which is brought to the surface soon bears as plentiful a crop as the former one. I have seen this occurrence at least six times following in the course of one summer, without being able to remark any diminution in the crop of weeds which succeeded each plowing, and without the species being destroyed in the following year. These operations have been constantly repeated for three years without the seeds of the weeds being entirely extirpated.

Those weeds which belong to the class of *annuals* in general only show themselves among the spring corn; the autumnal cereals are often entirely free from them, especially when the sowings have been performed sufficiently early to admit the development of the seed which was situated at the surface of the soil. This class of weeds cannot resist the winter; they invariably perish in the spring if not before. They are only found among the autumnal corn when the surface of the soil has been turned over afresh, or when it has been carefully reduced to powder, or the clods not broken until winter or spring, or, lastly, unless the seeds are deposited there by the action of wind or water; and even in these cases the weeds are never very plentiful, unless an unusual mildness of temperature has preserved them throughout the winter. The *biennial* weeds, on the contrary, do not attain their perfect development but with the autumnal crops, although they also spring up among the spring corn.

The most numerous of all the species of *annual* weeds are those which belong to the tribe of wild mustard and wild radish plants; various kinds of plants are included in this number, although the appearance of all is very similar. The wild mustard (*sinapis arvensis*) only thrives on strong, rich, moist soils; this plant, so far from attaining maturity on poor land, soon perishes there; indeed the seeds of it may be sown in such places with perfect impunity. It certainly springs up on poor land, but then it is speedily choked by other plants; whereas it completely overruns rich soils, and those which are strongly impregnated with humus, and injures if not entirely destroys the crop. This plant may easily be extirpated, because its seed not being enclosed in a thick, hard covering or husk germinates with great facility; neither is it altogether useless, because, perishing at the same time with the spring corn, its seed may be reduced to oil after having been separated by means of a sieve. Careful agriculturists always pull this plant by hand in its full vigor, before the cereals reach to any considerable hight; they then give it to their cattle for fodder, and it is found to be very profitable for that purpose.

The wild radish or jointed charlock (*raphanus raphanistrum*) vegetates on

sandy clays or clayey sands; and on all weak soils, however unfavorable the temperature may be, it is found to flourish; the weaker the soil, and the more unfavorable the weather, the sooner does it check the cereals. It is particularly distinguished from the wild mustard by the tough and membraneous cuticle which envelops its seeds, totally preventing the extraction of oil, or at any rate rendering it difficult; besides, the seed is smaller and not so oleaginous in its nature as that of the wild mustard; the stalk is rougher to the touch and more devoid of nutritive juices than that of the last named plant. It is, nevertheless, nourishing and agreeable to cattle; therefore fields infested with this plant are not altogether valueless, as they may be made to yield a good supply of fodder without the necessity of sowing any more seed, but simply by means of plowing and harrowing them several times in the course of the summer.

Land is also occasionally infested by various species of cabbage, cole, and some varieties of rape-seed.

For some years past these kinds of weeds have appeared to increase rapidly on the arable land in the north of Germany; in fact, it is now almost impossible to find a single field that is exempt from them. This evil may be chiefly attributed to sufficient care not having been taken to procure the seed with which the fields are to be sown quite pure; even these precautions will not, however, be always effective, as in many cases the land already contains a great quantity of these pernicious seeds. These weeds can only be diminished and extirpated by turning up the soil frequently during the summer months, deferring the spring crops, and, lastly, by pulling up all those plants with the hand which have otherwise escaped destruction, and which spring up in various places.

The corn marigold (*chrysanthemum segetum*) is a much more pernicious weed, but it is not so plentiful as the others. It grows so vigorously, is destroyed with such difficulty, and multiplies so rapidly and numerously, that it not unfrequently renders a soil totally unfit for the production of spring corn, and deprives it of all its value. This plant does not germinate until very late, and until the soil is tolerably warmed; but then it shoots up so vigorously that it soon chokes all those plants which had attained a tolerable degree of vegetation before it began to sprout; its strong vigorous shoots and leaves rapidly extend themselves over the whole surface of the ground, and appear to absorb all the nutritive matter contained in the atmosphere as well as in the soil. It possesses so great a degree of vitality, that if one of the plants be plucked while yet in the bud, the flowers will not only open and blossom, but even the grain will arrive at maturity. When a field is weeded, and these plants are pulled up and thrown together in a heap, they do not enter into decomposition or fermentation; on the contrary, those at the top of the heap shoot again, vegetate, and bear seed: so that the only way to destroy them is to bury them very deeply, or to burn them. The seeds of this plant will pass through the bodies of animals without losing their vitality, and thus the "chrysanthemum" is frequently propagated by means of the dung. In districts where this evil is known to exist in the neighborhood, but to which it has not yet extended itself, the most unremitting pains and precautions are taken to ward it off. If any horses or cattle come from places infested with this weed, all the excrements which they void are immediately burned, and the farmers refuse to purchase hay or straw which is likely to be thus contaminated. In order to prevent the multiplication of this plant, rewards are frequently offered for every corn marigold that is plucked up and destroyed.

When land is once overrun with this plant, it is extremely difficult to destroy it, especially in crop-lands, where different properties are intermingled, it cannot be done without very great sacrifices; nevertheless, it is not so thoroughly impossible as many persons seem to think. Frequent summer plowings and harrowings which always turn up a fresh bed of earth to the surface, destroy a great portion of the seed after its germination; this end cannot, however, be attained in one summer, even if the land is plowed every third week. Spring corn must not be sown between the two fallows; nor must any other produce be raised among which the "chrysanthemum" can possibly spring up and attain maturity, unless repeated and most careful weedings are bestowed on the crop.

Two examples cited in the "Annals of Agriculture of Lower Saxony," Vol. iii. p. 320, prove that if the proper degree of attention is paid, and the requisite care and precautions used, this evil may eventually be removed; but of course the

value of a soil infested with this weed is depreciated in proportion to the difficulty in extirpating it.

Another plant which is equally injurious, but which is more easily destroyed, is the wild-bearded oat (*avena fatua*). It usually grows among the spring corn; but is also often found among the autumnal crops. As its seed does not remain long in the earth, but easily germinates, and shoots when just below the surface of the soil, it may be entirely extirpated from a field in the course of a year, provided that as soon as it flowers, it is immediately cut down and given to the cattle, or stacked as dry fodder, a purpose for which it is well adapted: but if the seed is allowed to ripen and come to maturity, it readily drops out and sows itself before the cereals have attained their full growth. The seed of this plant is easily carried away by the winds, and freed from its husk or cuticle; the grains are so much disposed to become dilated by moisture and contracted by heat, that they have been used as a species of hygrometer. The seed of this plant is very frequently conveyed with the seed-corn from a field which is infested with it, to another which had previously been wholly exempt; in districts where this plant has once established itself, it is scarcely possible to extirpate it, unless all the farmers join together in endeavoring to effect that purpose.

Among those weeds which resist the severity of winter, and which, consequently, are chiefly found among the autumnal corn crops, the corn blue bottle (*centaurea cyanus*), the various kinds of camomiles (*anthemis, anthemis cotula, anthemis arvensis*), the ox-eye daisy (*chrysanthemum leucanthemum*), the cock's-comb (*crista galli*), the yellow-rattle (*rhinanthus cristagali*), the corn or red field-poppy (*papaver rhoeas*), the corn-cockle (*agrostemma githago*), are those which recent experience has taught us can exist for the greatest length of time in a soil without germinating, although their seed is of a tolerable size. The seed of all these plants preserves its vitality so perfect while embedded in the earth, that the utmost endeavors are frequently insufficient to free the soil from them. They are not, however, so injurious to the autumnal as some others are to the spring corn, because in the first named crops the cereals being vigorous and thick, and vegetating upon a healthy, rich land, soon get the upper hand: these weeds only thrive and spring up abundantly where the vegetation is weak and feeble.

The same may be observed with respect to rye-brome grass (*bromus secalinus*); its seed is frequently mixed and sown with the corn accidentally; but it often lies embedded in the soil, where it remains for an immense period of time, without shooting or germinating, unless it is brought to the surface of the soil. It often happens that when wheat which was considered as perfectly pure has been sown, more brome-grass than wheat has sprung up; whence has arisen the absurd opinion, that rye can be transformed into brome-grass. This plant thrives in those places where the land is so damp as to be prejudicial to rye, and becomes so strong and flourishing as speedily to choke the grain. In dry seasons an exactly contrary effect takes place; therefore, in dry situations and seasons there is scarcely any appearance of this weed, although the seeds which have been scattered over the land retain all their vitality. I shall pass over a number of other weeds which are propagated by their seeds, but which are neither so common nor so injurious in our climate as those I have already mentioned; neither shall I mention those which proceed from seeds sown accidentally among the cereals, or from seed preserved in the soil, all of which can be entirely extirpated by proper care and attention; as wild vetches (*vicia cracea*), the tufted vetch, the yellow vetchling (*lathyrus aphaca*), the rest-harrow (*ononis arvensis*).

Among the weeds which are seldom propagated by their seeds, because these latter rarely attain maturity, and which, nevertheless, overrun whole fields, and materially injure the land, we particularly notice couch-grass (*triticum repens*), and marsh-bent grass (*agrostis*). Every agriculturist must be aware how very difficult it is to extirpate the former of these weeds in a field that has once become infested with it, especially if the substratum or the situation of a soil renders it liable to suffer from humidity; in such a case the utmost care and pains bestowed on the fallow is often ineffectual. We shall point out the best means of destroying these weeds when we come to treat of plowing, or breaking up and loosening the soil; at present, all that we have to consider is their influence on the value of land. So long as a soil continues to be overrun with couch-grass,

it will not bear those crops which might otherwise be derived from it. Land thus infested is generally not poor, and it is still farther improved by the putrefaction of the roots of this weed. If, therefore, it can be fallowed at once, or only made to bear those crops which require careful weeding, a judicious agriculturist will find that he will not have to make greater sacrifices on it than on other land, he will only have to plow and harrow it rather oftener; but in forming a valuation of such land all these circumstances ought to be taken into consideration.

This evil is not so important to those who are about to purchase a farm or estate, as it is to those who are merely about to rent one, especially if they are only taking it on a short lease. Where the fields are damp, infested with couch-grass, and consequently cannot be cleared without difficulty, their intrinsic value is of course considerably diminished.

Lastly, among the most injurious of all the weeds that infest our fields is the corn-bind weed (*convolvolus minor*, or *arvensis*), the roots of which penetrate so deeply into the soil that it is almost impossible entirely to destroy it. It injures the cereals as well by its large leaves as by its long shoots, which entwine themselves round the blades of corn and drag them downwards.

The varieties of horse-tail (*equisetum*) mostly vegetate on soils in which the substratum is always damp; they do not appear to be very injurious to corn, unless by depriving it of that amount of space which is occupied by the blades of this weed; it absorbs little or no portion of the nutriment which the cereals ought to receive, because this plant derives its nutrition from the subsoil. Horse-tail is, however, very prejudicial to pasture land, both because cattle do not like it and because it is not wholesome for them.

Colt's-foot (*tussilago, farfara*, or *petasites*,) with its broad leaves, extends over a large surface, and can only be got rid of, with great difficulty, by means of incessantly digging up, tilling, and draining those soils in which it has once taken root; it generally grows on argillaceous and marly soils.

The dew-berry (*rubus cesius, fructo nigro, rubus fructicosus*), or the shrubby bramble, often extends itself very rapidly; it flourishes most on soils which contain marl or clay. It is very difficult to destroy this plant, because its roots penetrate so deeply into the soil, and each of them puts forth new shoots, which spring up in various places, and choke and destroy the cereals.

Among that class of weeds which are propagated both by means of their roots and their seeds, we find the corn-thistle (*seratula arvensis*), particularly eminent. This plant will seldom grow in any but rich clayey soils, and its presence may therefore be considered as an indication of fertility. Nature appears to have made a special provision for the preservation of this plant, by providing it with prickles, which prevent the cattle from touching it after it has attained a certain size. Numerous stalks and shoots spring from each of its roots, and the more these are cut while young, the more rapidly do they multiply. Besides, it produces an immense number of light downy seeds, which are carried about and disseminated far and wide by the winds, and thus sow themselves. A soil may become so infested with this weed as to cause all the crops sown on it to fail or to be greatly injured.

The various kinds of docks (*rumex*) also extend themselves over the fields, and their great and rapid multiplication is owing quite as much to the shoots thrown out by their roots as to the seeds.

There is an immense number of weeds, but we shall here content ourselves with pointing out those which are most liable to injure the crops which are raised on arable land; at some other time, we shall speak of those which infest and injure meadow land.

We occasionally find certain fields or portions of land to be full of stones. These, considered in an agricultural point of view, may be divided into two classes: first, those which cannot be removed by the operation of plowing; and, secondly, those which are loose and detached.

Those large stones which show themselves on the surface of land, and, what is still worse, those which are so covered with the vegetable soil as not to be perceptible, are exceedingly prejudicial to all the operations of tillage. They are sometimes at so great a depth below the surface of the land as not to interfere with superficial plowings; but when the plow is made to penetrate more

deeply, they impede its action; these stones must, therefore, be removed before the land can be properly tilled. Occasionally, immense masses of stone will be found to exist in the soil, which only appear, at the surface, to be mere pebbles, and are thus supposed by casual observers to be of trifling import. These cannot be dug out without considerable labor and expense, which can only be repaid or in any measure remunerated, in those places where the stone thus extracted from the ground can be advantageously used or sold: consequently, this circumstance ought to receive due consideration, when it is proposed to plow such land to a greater depth, and to make use of improved implements.

Those loose stones which give way before the plow and harrow, are exceedingly prejudicial to Agriculture, when they exist in too great numbers in a soil. They do not yield any nourishment to plants, and, therefore, may be reckoned as worse than nothing in the layer of vegetable mould of which they form a part. They are also prejudicial in consequence of the injury which they cause to the agricultural implements, in their impeding the action of the scythe, and compelling the reapers to leave the stubble very long. Therefore, whenever the agriculturist wishes to introduce a system of improved cultivation, he must endeavor to get rid of all these stones by having them picked up, or otherwise separated from the soil: this can, however, seldom be effected without considerable expense. Some persons have considered that it injured a soil to deprive it of these stones, and allege, in support of their opinion, that the office of the stones is to refresh the soil, and communicate heat to it as may be required; that they protect the seed, and have a tendency to retain moisture; but these assertions will not bear the test of inquiry. With respect to those experiments which are brought forward with a view of supporting this theory, there are so many facts and observations of a diametrically opposite nature, and which are well attested, that we cannot give to the former the slightest credence. We do not, however, mean to deny the utility of limestones in argillaceous soils, because the manure with which they come in contact, as well as the touch of the roots of the plants, gradually decompose them, thus ameliorating the soil, and affording additional nutriment to vegetables; but where the stones are of a silicious nature, as is too often the case, we must beg leave to deny their utility, at least until some positive experiments shall convince us of the contrary.

In describing the general surface of an estate, or drawing out an exact plan or description of a certain extent of land, founded both on the composition and on the constituent parts of which the soil is composed, and which may serve to guide us, not only in estimating the land, but also in choosing the proper system of cultivation for it, and the rotation for which it is best adapted, it is absolutely necessary to pursue some regular and systematic course of proceeding. If the land is not already divided into beds or portions which form a species of distribution of it, parallel lines must be traced upon it, about five, ten, or fifteen perches apart, according as the nature of the soil undergoes a greater or less change.

At the same time, a plan of the piece of land which is to be estimated should be drawn out on a tolerably large scale; that is to say, nearly four times the size of ordinary territorial plans. The parallel lines above mentioned must be traced on this plan, and intersected or divided into portions of from five to ten perches each: these portions should be numbered in rotation. Besides the men who measure the land, there must be two others, one with a spade to dig up, and the other with a basket into which to receive the samples of soils that are raised. The surveyor sketches the plan or chart, and draws up the reference book, unless some other person is employed expressly for the latter purpose. The agriculturist observes the nature of the soil, and directs the whole operation. As soon as he perceives any change, he stops, and desires that this spot may be marked on the plan, and then enters into a more accurate examination of the alteration: should it appear to him to be necessary so to do, he causes some of the earth to be turned up with the spade; and if he considers that a yet closer analysis will be beneficial, he places about a pound of the earth in a horn or little bag, on which he marks the number or letter of the station. The places where these variations in the nature of the soil occur, must be marked out on the plan, by the surveyor, with all possible precision; neither must he omit to signify whether this change takes place at once, or comes on gradually. Whatever other remarks are considered necessary, as those which relate to the properties of the

soil, or the changes produced in them by the alteration, &c., should be inscribed in the reference book, under the number appertaining to the portion of land in which they occur.

In this manner the whole of the land is passed over in the direction of those parallel lines which were traced upon it, and thus, in the course of this operation, a draught of a geometrical plan is formed.

With regard to the plan itself, it may be drawn out in various ways; but the best mode of proceeding is to designate the various component parts of which the soil is composed by water colors, and indicate the almost insensible changes of composition by shades of color. The hights and hollows may be signified by what is called "ground-lines," properly shaded; the greater or less quantity of humus with which the soil is impregnated by black dots, which must be placed nearer to one another the more humus there is in the soil; thus all points worthy of notice will have their distinctive signs. With such a plan, the agriculturist will always have an exact picture of his land before his eyes, and can therefore make those arrangements which he thinks will be most suitable to the nature of its different parts.

It is not impracticable likewise to trace out on this plan the direction of the declivities and water courses, &c.; but if it is deemed necessary to have all these things indicated in a more detailed manner, the levels and hights must all be measured with instruments proper for the purpose. These levels may be taken in different directions, and then the mere vertical profile is given. If the substratum of the soil undergoes any change, and it is thought necessary to analyze and make special mention of it, that may very easily be done by shadowing the profile of the plan or chart with colors which shall indicate the thickness of the various layers. In this case the auger or land-sound may be used in taking the level, and introduced into the soil as deeply and as often as is necessary. This can be done without any great difficulty.

Where the constituent parts of a soil cannot be distinguished with sufficient accuracy by means of its external characteristics, or where it is otherwise deemed expedient to submit it to a more minute examination, it must undergo a chemical analysis. But if the samples which have been taken from different spots are compared together, both in a state of moisture and of desiccation, it will generally soon become evident which are those that are of an homogeneous and also those that are of a different nature, without the necessity of having recourse to chemical analysis.

No operation will fully compensate an enlightened agriculturist for the trouble which it costs him as this mode of proceeding; he will here find a solution of all those phenomena which previously appeared inexplicable, and will thus be enabled to apply an efficacious remedy to the various impediments and inconveniences which he may meet with in the cultivation of his property.

SECTION IV.

AGRICULTURE.

THE term "Agriculture," considered in its strictest sense, signifies the tilling and preparing the soil, and rendering it capable of producing those crops which are required from it in their highest state of perfection.

This effect is produced in two ways: the first, which is designated "chemical Agriculture," or in other words, and in common language, the "amelioration of the soil," consists in adding to it all those substances which tend to increase its fertility, by incorporating nutritive matter and juices with it, or developing and calling into action those which it already contains; the second, which is called

"mechanical Agriculture," or the cultivation and tillage of the soil," consists in loosening the earth by means of plowing or digging, or otherwise working it, so as to enable the roots of plants to penetrate it without difficulty, and seek and appropriate to themselves those substances which are most analogous to their nature.

We shall enter fully into these two subjects or divisions in the course of the present chapter.

PART I.—ON MANURING AND AMELIORATING THE SOIL.

Manure acts upon the soil in two ways:—

First, by communicating to it those juices which are calculated for the nutrition of plants and vegetables:

Secondly, by the chemical action which it exercises on those substances contained in the soil, decomposing them, and re-combining them under new forms, and thus facilitating their introduction into the suckers of plants; and, perhaps, also by communicating that degree of energy and activity to vegetation which enables it to take up and appropriate the suitable nutritive juices.

Some kinds of manure appear to produce only one of these effects, or at least to produce one in a far greater degree than the other; while others, on the contrary, seem to produce both.

We generally express the effect of manures on a soil by saying that they fertilize it, and many persons would be satisfied with this expression; nevertheless it is exceedingly necessary, both for the sake of theory and practice, that we should endeavor to define the way in which each variety of manure produces its peculiar effect, and under what circumstances it acts in one way rather than in another. It is only by means of such knowledge that we are enabled to account for various facts which are to all appearance contradictory; and can learn to make a prudent selection among all the various proceedings which are to be followed in the use of any one particular kind of manure.

The English have instituted a very good comparison when they compare manures belonging to the first class to food, and those appertaining to the second class to salt, spices, or stimulating drinks.

All organic substances which have entered into a state of putrefaction or decomposition, contain the elements necessary for the re-production and perfecting of the vegetables which we cultivate. If, by means of seeds or roots, we bring the germs of some particular plant in contact with these substances, and all the other details appertaining to the operation are properly conducted, plants of similar species to that which we set will be produced. All soils contain the aliments proper for every kind of plant, but not in equal proportions; that is to say, every soil does not contain similar proportions of alimentary substances. In fact, it is well known that some kinds of land favor the vegetation of one plant, while others are peculiarly adapted to a totally different kind.

Vegetable decomposition or manure, appears to act on plants solely as an aliment; it does not seem to contribute much towards the development of those parts which the soil already contains, and which are formed of the residue of previous manurings, now become insoluble from the action of various causes.—Animal decomposition or manure, on the contrary, acts on the soil as well as on the plants which vegetate there. It not only contains all those substances which are indispensable to the vegetation of plants, some of which, certainly, are contained in vegetable manure, although in smaller proportions; but it also favors the decomposition of the insoluble humus, and communicates a greater degree of energy to the vegetation of plants.

Mineral manures which do not contain any organic bodies act solely, or at least essentially, by improving the texture of the soil, rendering those parts of it soluble which were previously insoluble, and favoring and accelerating decomposition.

Every organic body is formed by the combination of three, four, or more elementary substances united by vital power in certain determinate proportions; but when the vital principle ceases to exist and to act upon them, those combinations are resolved into their original elements, and again submitted, either wholly or in part, to the organic laws which govern those elementary bodies. These latter subsequently unite, either in the form of simple combinations, that is to

say, two and two, according to the laws of affinity, or in more compound combinations of an entirely new character. These latter, without appertaining to life, owe their existence to it, and in their turn assist in supporting the vital principle. Vegetables derive their chief nutriment from the combinations resulting from the decomposition of animal and vegetable life, and in the natural course of things become, in their turn, the food of men and beasts.

These newly-formed matters, viz., the more or less decomposed manure and the humus which arises from it, vary in their nature according to the different substances from which they were derived, and the circumstances which influenced their formation.

The progress of their transformation is designated by the terms "decomposition," "fermentation," and "putrefaction." We shall not enter into a definition of these terms, but content ourselves with making the following remarks:—

The conditions of the state which we designate by these words are, total absence of vitality, *heat, moisture,* and a *species of combination with the atmosphere.* According as these concomitant circumstances increase or diminish in intensity, this process will undergo various modifications, be accelerated or retarded, and be attended with different results.

Vegetable bodies pass through various degrees of fermentation before arriving at the last of them, viz., putrefaction, and becoming entirely decomposed or reduced to a state of mould or manure; a state which ought not to be regarded as permanent and unalterable, but merely as having some duration.

Animal bodies, on the contrary, pass over the first degrees of fermentation altogether; or, at any rate, are but so very slightly affected by them that they are scarcely perceptible. These substances enter at once into a state of putrefaction, and cause all vegetable bodies with which they are in contact to do the same.

This putrefaction and the matters which result from it, also experience various modifications, which are dependent on the strength of the combinations taking place in them, and the intensity with which heat, moisture, and atmospheric air act upon them.

In the open air, and without the intervention of moisture or of any additional heat, the process of fermentation and putrefaction is not perceptible; a species of decomposition does, however, take place, which is similar to slow combustion. This decomposition produces a very different matter to that which is the result of putrefaction, and one which is smaller in quantity, because the greater part of the carbon combines with oxygen, and evaporates under the form of carbonic acid.

The greater degree of rapidity with which animal bodies are decomposed by putrefaction, doubtless arises from these bodies being but slightly complicated in their nature, from their being composed of an infinite variety of substances, and, among others, of those numerous vegetable preparations which enter into the food of animated beings. The product of this putrefaction is different: it has a more energetic effect on plants, because it acts not only as an aliment, but also as a stimulant; and this will account for the fact of its being very rapidly and easily exhausted. The dung of animals is a very active, but far from being a durable manure.

All animal bodies, as dead carcasses, flesh, intestines, the refuse of the shambles, &c., when in a state of putrefaction may be converted into manure; and those manures which are thus formed are far more active than any others. These substances may be employed for this purpose; but in general the excrements and urine of animals obtained from them during life are set aside for manure, because a large quantity can thus be obtained and at a much less expensive rate.

It is found to be very advantageous to mix these excrementitious substances with the remains of vegetable matters: by which means the latter are led to enter into a more rapid state of putrefaction, and do not lose so much of their actual substance; while the fermentation of the animal bodies, which would otherwise be carried on with too great rapidity, is somewhat retarded. Manures thus formed are called "natural manures," in order to distinguish them from others which are termed "artificial." This appellation is not, however, bestowed because they are more simple than others, or because they require less care and skill to be bestowed on the preparation of them, but merely because they are

the best known, and indeed, among many persons are the only kind of manure which is known and used.

Those excrements which are voided by animals through the intestinal canal, are composed not only of the residue of the food which they have taken and of that portion of its filaments which could not be decomposed, but also of molecules of the body of the animal itself, which are deposited in the intestinal canal after having performed their office; consequently, these excrements may be said to be entirely composed of animalized substances, and even in animals fed almost entirely on vegetables will be found to possess more of the animal than the vegetable nature. The properties of the dung, however, depend to a certain extent on the manner in which the beasts are fed, and their condition and breed. If the animals are so fed that their stomachs contain a very small portion of nutritive juices, but an immense quantity of fibrous matter which is not easily digested or decomposed, as, for example, straw, and the dried stems of plants without any admixture of grass or corn; these substances will pass away from the intestinal canal almost in the same state in which they entered it, and become less animalized in proportion as the lean and ill-conditioned body of the animal parts with less of the fleshy particles. But even the small admixture of animal matter thus obtained suffices to give these excrements a greater and more rapid tendency for entering into a state of decomposition or putrefaction. But the excrementitial matter voided by animals which have been brought into good condition by nourishing food full of gluten, farina, albumen, mucilage, and the saccharine principle, and in which a large number of molecules are daily reproduced and detached; the excrements of such animals, I say, furnish an infinitely more active manure, and one which contains a much smaller proportion of vegetable and fibrous parts. Hence arises the striking difference which exists between the dung yielded by cattle put up to fatten, or which are in good condition, and that which is voided by lean, badly-fed animals. A proportionately greater quantity of litter may be added to the former without impeding or retarding that uniform fermentation which leads to putrefaction.

It is generally customary to mix urine with the solid excrements. This liquid, which is in fact composed chiefly of water, likewise contains a substance which is peculiar to itself, and various other very active matters, and several phosphates, but particularly the phosphate of ammonia. By evaporating urine it has been found that not only the liquid itself, but those salts also which are obtained from it in small quantities are very favorable to vegetation. But Dr. Belcher, in his "Communications to the Board of Agriculture," says that plants may easily be too highly stimulated and even destroyed by the action of this fluid. He attributes this effect partly to a small yellow insect frequently met with in urine. Numerous experiments seem to prove that the various matters contained in this fluid are most efficacious when mixed up with the solid excrements and collected by means of the litter, or of certain substances peculiarly adapted for the purpose; these substances having a strong tendency to decompose one another, give rise to the formation of new compounds.

Common manure is composed of these two kinds of excrements and of those vegetable substances which are used as litter, as straw, fern, or dry leaves, but chiefly the first of these three; this mixture is commonly termed stable-manure, a name by which we shall henceforth designate it.

Stable-manure varies in quality according to the kind of animals by which it is produced, even where these animals have received the same kind of food and of pasturage.

Only a few of these varieties of dung have been decomposed and accurately analyzed. The dung of horned cattle has been analyzed by Einhoff and myself; it will, however, be necessary to conduct the analysis with greater accuracy and with the aid of a pneumatic apparatus before we shall be able to institute an exact comparison between the different kinds of dung and their component parts.

Among the numerous phenomena exhibited by stable-manure, we shall only notice those which are easily observable, and which serve to distinguish the various species from one another.

When horse-dung, in a proper state of humidity, is exposed to air of a moderate temperature, it soon enters into fermentation. So great a degree of heat is engendered by this process, that the moisture and all the volatile matters are ex-

pelled, and, if the dung is not watered, instead of assuming the form of a thick paste or black-butter, as it is commonly called, it becomes friable, pulverulent, and wastes away, so as to leave scarcely anything but ashes behind; when it has not been pressed together, but is so loose that the atmospheric air can penetrate into its substance, it decomposes unequally, becomes partially carbonized like turf, and covered with a considerable quantity of mould, which, experience has repeatedly shown, greatly impairs its manuring qualities. It is of a much more fertilizing nature when produced by vigorous animals which consume a considerable portion of corn, than it is when produced by such as are fed with nothing but grass, hay, or straw; but even in the latter case it is still valuable as a manure. When manure of this kind is laid on the ground before its decomposition is completely effected, it produces a very rapid effect, and greatly accelerates the growth of plants through the heat which is developed in the ground after the dung has been buried there. This circumstance renders manure composed of horse-dung peculiarly beneficial to moist, cold, sterile, clayey soils, the faults of which it corrects, while at the same time the soil checks the too violent action of the manure. On the other hand, this kind of manure is often exceedingly injurious to soils of a dry, chalky, sandy, or calcareous nature; it there accelerates and stimulates the growth of the plants in the early stages of their development so much, that when the action ceases the process of vegetation becomes feeble and languid. The effects of such manure are also very transient, because it becomes consumed by the very energy of its own fermentation, and leaves but a very trifling residue. The only soils in which this does not take place, or in which the effects of manure composed chiefly of horse-dung are at all durable, are in those of a moist and tenacious nature. Manure of this description is exceedingly beneficial to soils which contain a large quantity of insoluble humus or vegetable mould, because the ammonia which it contains greatly facilitates the decomposition of this substance.

If the dung has reached that stage in which fermentation, accompanied by rise of temperature, or the disengagement of heat, is at an end, it still leaves a residue highly favorable to vegetation in all the soils with which it is incorporated; but this residue is very small in quantity.

When the dung is to be used by itself, it must be carried to moist and clayey soils as soon as its first stage of fermentation has commenced, and an effect which soon takes place, and there buried. It ameliorates the land by its mechanical action, rendering the soil looser and lighter by its continual fermentation and the heat which it engenders; besides, the repeated plowings which are requisite, in order that it may be thoroughly mixed and combined with the soil, contribute materially towards the goodness of the crops sown on that land.

But when it is to be used upon warm, light soils, the most advantageous mode of employing it is to mix it with vegetable substances which still retain their succulency, or with earth, and especially with turf. For this purpose the dung should be mixed with the substances just mentioned, and heaped up in successive layers, care being taken to protect it from too free an access of air, and to moisten it whenever the weather is too dry. By this course of proceeding a very active compound will be obtained, which is permanent in its effects and exceedingly well adapted for light soils.

Stable-manure produced by horned cattle also begins to ferment very soon, provided that it is close and uniform in consistence, and contains only its proper moisture; but its fermentation is less rapid, and develops less heat than that of horse-dung, consequently the moisture of this kind of manure does not evaporate any thing like so rapidly, and it does not require watering, neither does it fall to powder, but rather assumes the form of a tolerably consistent paste, which is commonly called black-butter. So long as it is kept in a compact heap there is no danger of its being rendered pulverulent by desiccation; and when its moisture is entirely evaporated it presents the appearance of turf, and almost that of coal. Its specific gravity is greater than that of water, both when it is fresh, provided that it has not been mixed with straw, and also when it has undergone decomposition, and the tubular stems of the straw have been converted into filaments.

Its effect on land is less rapid than that of horse-dung, but proportionately more lasting. The different kinds of crops, too, for which it may be used, are more

numerous and more various in their nature. When this manure has not been very carefully and minutely divided, it is found in the soil in a turfy form, and in lumps of greater or less magnitude two or three years after it has been placed in the ground. When placed in the soil, it does not appear to produce any very sensible increase of temperature, and for this reason it is peculiarly and, we may say, exclusively adapted for the manuring of warm soils. It has been and is commonly said that cow-dung cools soils of the latter description: a more correct mode of expression would be to say, that it does not heat them. When buried under the layer of vegetable mould in tenacious and clayey soils, it will probably not appear to produce any effect, at least until it is brought into contact with the air by repeated plowings. When buried in an early stage of its decomposition, the tubes of the straw with which it is combined serve to keep up a communication between the dung and the air, and thus its decomposition appears to be accelerated. Straw which has not been bruised, and the tubes of which are entire, also produces a beneficial effect on these soils.

Sheep-dung when kept in a compact heap, and retaining its own moisture, decomposes rapidly; but where it is loosely heaped and its moisture has the means of escaping, the process of decomposition is effected slowly and with difficulty. When placed in the soil or voided over it, it seems to exhaust itself very rapidly, and produces a speedy and energetic effect. When used abundantly it often gives too much vigor to the first crop, and accelerates vegetation in too great a degree; it should, therefore, be used upon the land in smaller quantities, both as regards weight and volume, than any of the other kinds of manure. In most cases its action does not extend beyond the second crop.

The excrements, and especially the urine of sheep, disengage an immense quantity of ammonia. This circumstance makes the use of sheep-dung very advantageous, especially on soils which contain insoluble humus or vegetable mould.

The dung obtained from sheep-folds is generally of two kinds. That which forms the upper stratum is brittle, dry, and undecomposed; that which forms the lower stratum, on the contrary, is solid, moist, and adhesive. Unless great care has been taken to stir it up, so as to form into an homogeneous mass, it must not, on any account, be spread indiscriminately over the same field. The dry portions of it produce very injurious effects on elevated lands of a warm, dry nature; but are more beneficial on moist soils, particularly if they are slightly sour or acid. A large quantity of this dry sheep-dung may be spread over soils of the latter description, without occasioning any inconveniences; but the decomposed portion, or under stratum, must, on the contrary, be spread but very thinly over any kind of land, otherwise it tends to lay the corn.

Opinions are much divided with respect to the qualities of pigs'-dung mixed with straw. Some authors speak of it as being very energetic in its action, while others attribute but very trifling effects to it. The qualities of the dung yielded by all animals, are greatly influenced by the kind of food which they consume; but this fact is more perceptible in the dung of pigs than in that of any other kind of animal. It is not a matter of indifference, either as regards the quantity or quality of the dung, whether it is produced from swine that are poorly fed, or from such as live upon rich food. The quality of the dung also depends in a great measure, upon the methods resorted to for the purpose of collecting it. If care be taken to keep the straw of the litter dry, by providing some means of carrying off the urine rapidly, either by letting it run through holes made in the floor, or else carrying it off by means of gutters, &c. the straw retains but a small portion of animal matter, and is capable of producing but little more effect than that of ordinary rotten straw. But if, on the contrary, the liquid portion of the excrements are mixed with the straw in such manner as that there shall be no possibility of their running off, and the dung is placed in a situation which is favorable to its decomposition, a very active compound is produced, which, after having undergone its first fermentation, is entirely freed from that acrid quality which the dung of swine is said to possess.

In most farming establishments the quantity of dung produced by poultry is but small; but, on the other hand, this dung is very active and of great value.—It is very different from that of quadrupeds, and contains a peculiar substance which seems to be mainly composed of albumen. We possess an exact analysis

of this kind of manure made by Vauquelin. This chemist discovered a marked difference between the dung of cocks and that of breeding hens; a difference which does not extend to hens which do not lay eggs. Poultry dung, although used in small quantities, exerts a surprising effect, provided that special care is taken to divide it minutely; but this effect is much less sensible where the dung is placed in the ground in large lumps.

In order to make manure derived from this dung useful, it is necessary to divide it as minutely as possible, and spread it over the ground without burying or covering it up.

Human excrements, or nightsoil, are known to make a very active manure; they differ essentially in composition from those of all domesticated animals.—Their own quality probably varies according to the food from which they are produced. It is an undeniable fact that the excrements voided by human beings who live chiefly on animal food, are much more active and efficient as manure, than those which proceed from persons whose diet is principally composed of vegetables.

Those who know how to turn these fecal matters to the greatest possible account, and can surmount the disgust which the use of them occasions, prefer them to all other kinds of manure. It has been asserted that the excrements of a man are capable of producing a quantity of vegetable matter, sufficient for his own support, but it is easy to see that this assertion is greatly exaggerated.—There is, however, no doubt that if these excrements were carefully collected, and turned to the greatest possible account, the quantity of aliment obtained from their use would be so great, that Europe would be capable of supporting another population of human beings. At present, they are generally left to decompose, without being turned to any account; or are carried off, by drains, to large rivers, and thus to the sea.

The disgust occasioned by the use of nightsoil arises, in part, from the offensive smell which it, at first, gives out, and from a prejudice to which this disgust has given rise; viz., that manure thus formed communicates an unpleasant flavor to the plants which are nourished by them. Another cause of objection arises from most persons being unacquainted with the proper manner of using this kind of manure, to which cause most of the bad effects which it produces may be attributed; at all events, it does not yield benefits proportionate to the trouble which it occasions.

Nightsoil produces surprising effects when carried to the land before its fermentation is completed and spread over it with care. The best way of using it is to form it into a kind of compost, by mixing it with other substances, and especially by making it into heaps with turf, and adding a small quantity of burnt lime. By this means the superfluous energies are reduced to the requisite standard, and the effect extended over a greater space, without, however, there being any danger of the energy of the active matters which it contains being lost or impaired by this diffusion. This manure then loses its fetid odor, and becomes divided and mixed up with the other substances and forms a fertile soil.—The best way of using it is to spread it over the ground without covering or burying it. It should be mixed up several times, and all the substances thoroughly mingled together before it is used.

When nightsoil is spread over the heaps in which the dung of various kinds of cattle is collected, as is generally the case in places where these matters are not altogether thrown away, it does not produce anything like that effect which might be expected from it if it were more divided.

Large quantities of nightsoil may be obtained in towns; sometimes it may even be obtained gratis, but even then the carriage of it renders it expensive.—In the country, in farms and villages, it is always advantageous to prevent the loss and evaporation of this matter; for this purpose it should be collected in privies, whence it may be taken when required, and mixed up with earth dug from ditches and a small quantity of quick-lime. This mode of proceeding prevents the disgust which would be occasioned by seeing human excrements lying about the buildings and hedges.

In the neighborhood of Paris there is a large establishment in which a very active manure is manufactured from nightsoil. It is made in the form of powder, and for that reason is called *poudrette*. The excrementitial matter is

placed on an inclined plane covered with stone slabs, and there made into heaps in order that it may ferment, and when dry is spread out over a greater extent of surface: a harrow is then passed over it to break it up; it is subsequently placed under cover, where it is frequently heated afresh and thoroughly dried. It is then reduced to powder, which resembles brown tobacco in appearance, and sold to farmers, and particularly to gardeners, who, to judge from the price which they pay for it, certainly must derive immense benefit from the use of it.

The inhabitants of Belgium also make great use of this kind of manure.—They import and procure it from considerable distances even in the form of a paste, and go to fetch it in carts and boats without caring for the offensive odor which it exhales. They either use it in the form of compost, or mix it with a large quantity of water. It is highly valued in China and Japan, and hence has been called "Japan manure."

We now return to the process connected with stable manure, the largest and most important part of which is furnished by the horned cattle.

The dung of horned cattle is usually collected by mixing it with straw. Even though it might be advisable to depart from this method for the sake of having the cattle more warmly lodged, and providing them with more comfortable beds, even if this method should not be attended with the greatest possible convenience, it is nevertheless to be preferred, because the mixture accelerates the decomposition of the straw, prevents the evaporation of the dung and its volatile ingredients, and therefore contributes to increase its goodness. The tubes of the straw in particular absorb the liquid portions of the urine, which there deposit their most active and efficient parts.

There are a great many different methods of storing up and preserving this kind of dung. Some persons keep it for a considerable period in the cow-house, covering it every now and then with a fresh layer of straw; it thus accumulates to a considerable hight, so that the cattle are soon raised above the rack. To obviate this inconvenience, movable cribs are made which can be raised at pleasure. This method is resorted to merely for convenience sake; it avoids the necessity of clearing out the dung as often as would otherwise be necessary, enabling the farmer to cart it all at once, and thus saves trouble. It is thought, too, that the quality of the manure is improved by this method. The process of decomposition is commenced by the action of the moisture naturally contained in the dung, and as it is then less exposed to the atmospheric air, it loses little or nothing by evaporation; it even absorbs the dense vapors which exhale from the cattle and collect near the ground. These facts are indisputable, and the fear entertained by some persons that the vaporous exhalations arising from the dung may be injurious to the animals, is quite as groundless. There is no offensive smell observable in the stables; the air contained in them is always perfectly pure and respirable, provided that they are properly ventilated; which, by the way, is generally the case. The manure thus obtained, especially that which constitutes the lower stratum, is of an excellent quality; and by the time that it is removed from the cow-house it has passed that stage of fermentation in which it evaporates most quickly, its volatile parts having already entered into combination with the solid matter.

But this method cannot well be employed when the cattle are supplied with a considerable quantity of food composed chiefly of succulent and juicy vegetables, unless they are allowed an enormous quantity of straw for litter; for the amount of dung produced by cattle receiving this kind of food is so great, that its moisture cannot be properly absorbed by the litter, and consequently the cattle sink into it, and are always standing in a slough.

In order to realize all the advantages attendant on keeping the dung in the stable, and at the same time to avoid the inconveniences just mentioned, the mode of constructing stables or cow-houses mentioned by Schwertz in the second volume of his "Agriculture of Belgium," is certainly very convenient. By the side of the space assigned to the cattle, and behind them, is a space at least as broad as that which they occupy, but a little lower; it is in this space that the dung is deposited as it is removed from under the cattle. It is here, too, that the urine and the moisture of the stables collect. In the same place the dung usually undergoes decomposition, and thence it is carried directly to the fields which it is destined to manure. Were it not that in the greater number of agricultural

establishments the adoption of this method is prevented by the expense which the erection of such buildings would entail, an expense which would be double that of those which are in common use, this method would decidedly merit the preference over all others, and would be worthy of universal adoption. If the stables are sufficiently large to admit of the dung being left in heaps behind the cattle for a week or a fortnight, this must be looked upon as a great advantage, because by that time the dung will have passed that stage of fermentation in which its evaporation goes on with the greatest rapidity.

The dung should, therefore, be left in the stable as long as possible, because, the longer it remains there, the more it is improved in quality. But this consideration ought always to be regarded as subordinate to the imperious necessity of keeping the cattle in a proper state of cleanliness, and the stable dry. If the animals are allowed to stand in a state of filth, much more will be lost by the diseases entailed upon them than can possibly be gained by the increased value of the manure. Damp stables or cow-houses engender serious swellings and inflammation in the thighs, which we know, from experience, often turn out fatally. It is also a well attested fact, that when cows are badly housed and not properly littered, their milk becomes bad.

If the dung is suffered to remain under the cattle, great care must be taken that it does not collect in larger quantities under their hind, than under their fore-feet, because, in such a case, the animals will be placed in an attitude which is altogether contrary to their nature. This inconvenience is the more likely to happen because the excrements fall behind the cattle, and, consequently, the cow-herd strews a greater quantity of straw there in order to cover them. Hence, then, it is very evident that it is only when the cattle are fed on dry food that it is possible to leave the whole of the dung under them; unless, indeed, the stable is floored with planks, and has beneath it a hollow space into which the water can run through the interstices of the boards. This last named method is pursued in countries in which the dung is of but trifling value, and where, consequently, but little importance is attached to it.

But the practice usually adopted, is to carry the manure at once from the stables to places destined for its reception, where it is allowed to remain for a certain period in heaps of various sizes, previously to its being carried to the land which is to be manured.

These receptacles for manure are arranged in various ways. Sometimes they are large excavations, and then they form actual dung-pits. This form is positively injurious, not only because the moisture which collects in these pits checks the fermentation and decomposition of the manure, but also because the manure is too much shut out from contact with the atmosphere.* Besides, this arrangement renders the carting off of the dung an operation of much greater difficulty, the manure frequently being so saturated with moisture that its most fertilizing parts ooze away drop by drop as it goes along the road. Indeed, the inconveniences attending these dung-pits are so great and manifest that they are rarely used as receptacles for the dung of horned cattle, excepting in places where there is not sufficient space to allow of the manure being spread out and made into heaps.

Some persons, aware of the disadvantages attendant on a very damp situation, have recourse to the opposite extreme, and lay their dung on a flat or even on an elevated surface; but in such situations it loses too much of its moisture, and becomes deprived of its most active ingredients by evaporation.

The most advantageous arrangement seems to be to have the place in which the dung is to be kept, slightly hollowed out. There should be a trifling inclination on one side towards the centre, and at the bottom of this an opening through which the superfluous fluid may escape into a basin or reservoir prepared for its reception.† The whole should be surrounded with a raised border to prevent the admixture of moisture from other sources. Where the influx of extraneous water or fluid can be entirely prevented, the humidity of the dung will

* So far from considering it any disadvantage to keep the dung shut up, at least to a certain degree, from all contact with the atmospheric air, I am rather inclined to recommend such a course of proceeding; provided that at the same time a quantity of urine and water be left in it sufficient to favor its fermentation and decomposition, but not so great as to retard either of these processes.

† The pits intended to receive the urine and other liquids proceeding from manure, are commonly termed *fosses à lizée*, and the fluids thus contained are distinguished by the name of *lizes*. [*French Trans.*

rarely become too great, even if the whole quantity of urine running from the stable or cow-house is mixed with it, provided that the cattle do not live upon very watery food, such, for example, as the residue of the distillation of brandy from grain. Dung absorbs the natural moisture of the excrements as well as that which falls immediately from the atmosphere, and, by the heat which it disengages, causes the superfluous portions to evaporate. I am convinced that the best way of turning the urine to account, is to incorporate it with the mixed dung and litter. The amount of liquid which on this plan will run from the heap, is inconsiderable, excepting in very wet weather, when it will be collected in the reservoir provided for that purpose; and if the dung heap is laid on a slope, no farther arrangement is necessary, as the moisture will drain through it quite sufficiently.

It has been proposed to construct roofs over the dung-heaps, which in some instances have been carried into effect. These roofs are intended not only to defend them from the rain, but also from the rays of the sun; but they present considerable difficulties where the dung-heap is large; and it is impossible to protect the loads of manure, as they are brought from the stables, particularly as the same load should consist of a portion from several stables.*

The dung-heap should be placed at one extremity of the stable, and with room only for a loaded wagon to pass between. The road to it should be paved, and slightly elevated, to prevent the water that falls from the roof of the stable from running into the dung-pit; this water should, therefore, be carried off in a different direction. Covered drains should pass under the road, to convey from the stable into the manure, the waste urine that has not been absorbed by the litter.

If the dung is not carted till it attains an advanced degree of decomposition, it is necessary that the receptacle for it should be divided into several compartments; that each should be filled and emptied in its turn; or, otherwise, fresh dung would have to be carted with that which was rotten, or much time would be lost in separating them.

Sometimes separate places are appropriated for the reception of different species of manure, particularly that from horses and pigs, and sometimes the different sorts of manure are all united in one place. When the soil varies much in quality, and there is sufficient space, it would be well to separate the manure-heaps, and to devote each separate heap to that part of the land to which, as we have before shown, the manure would be most appropriate. Horse-dung should be deposited in a pit, or narrow deep ditch, not only to preserve the moisture, and to keep it cool, but also that it should be more condensed, and less exposed to the atmosphere. By this means, its fermentation and putrefaction will be rendered slower, and the mass will be more compact, particularly if from time to time care is taken to water it; and if it is wished still farther to retard the fermentation, it will be well to mingle with it the dung and urine from hogs. In this manner the manure from these latter animals, which is cold, and not readily fermented, becomes quickly decomposed; and the mixture of the two will form a very valuable compost.

In ordinary circumstances it is more convenient to mingle the different species of dung uniformly in the heap, so that the defects of one sort of manure may correct those of another; and the result will be a regular and well-digested compound. It is a general custom to keep the manure from sheep separate; and in many rural districts the sheep-fold is separated from the other buildings, and the dung is left under the animals all the winter, taking care to cover it with fresh straw, that they may lay dry. The removal of the dung of sheep during winter causes great inconvenience, even when the sheep leave the fold during the day, for when the dung is accumulated and removed, it exhales strong ammoniacal vapors, which much disturb the sheep when they return to the fold.

However, if it can be so arranged as to avoid these inconveniences, much benefit will be derived from mingling the dung of sheep with that of other animals; and all who do so, are sensible of the advantage.

* Most persons who recommend new methods to be employed in Agriculture or rural affairs, generally content themselves by considering the effects, without comparing them with the expense at which they are to be produced. In this case, it is very doubtful whether the expense of such a construction, and the annual charge to keep it in repair, considering the constant exposure to the hot vapors arising from the dung, would not more than counterbalance any advantages to be derived from it. [*French Trans.*

The experiments which I have tried, and published in the first volume of "*L'Archive d'Humbstadt*," and the observations that I have since made on the subject, have fully convinced me that manure acquires more strength, and diminishes less in bulk, when it is protected as much as possible from the atmosphere during fermentation, and till it has developed the greater portion of the volatile parts. I think, therefore, that covering it with earth, where it does not cause too much labor, is useful; but, as it is always attended with inconvenience, it will be found sufficient to spread the manure evenly, on a surface proportioned to the quantity to be deposited. As long as the fresh manure remains at the surface of the heap it does not sensibly ferment, and it prevents the portion beneath from coming too much in contact with the atmosphere; the gases which disengage themselves, with the exception of the ammonia, which in such a situation is but slightly developed, are heavier than atmospheric air; they, therefore, remain above in the upper layer of the heap, which prevents their being lost; and it is very probable that they are again absorbed and form new combinations. There is no sensible smell from a dung-heap thus constructed. Air collected immediately above the heap has hardly any effect on lime-water, nor does the application of nitric acid discover any ammoniacal vapors; it is only on the turning over the manure that these effects are produced. This proves, that whilst removing, much carbonic acid, azote, and hydrogen gas are disengaged; but that whilst it remains stationary, and partly protected from the atmosphere, these gases, instead of being evaporated, merely enter into new combinations.

It is of great consequence that the dung should be equally spread over the whole surface, and not thrown on in separate heaps; for between these heaps there will always be vacant places, which will soon engender mould, which much deteriorates the quality of the manure. Manure thus deposited is much improved by being condensed; it is, therefore, a good plan to surround the heap with a balustrade, so that the cattle can be driven over it. I am aware that some authors consider this practice as detrimental; but I cannot agree in their opinion, having, from a place where several carts passed every day over the heap, obtained manure of the very best quality, and perfectly decomposed. When the dung-hill has arrived at a hight of five or six feet, it is well to cover it with a coating of earth or turf, which will absorb the vapors as they rise; and when the manure is carted, the turf, which is not entirely decomposed, should be placed at the bottom of the pit, when it will become a very rich soil.

To prevent the loss of any of the liquid parts of the manure, it has been recommended to have the floor of the dung-heap paved, or even cemented, that they may not filter into the earth. If the soil is clayey, this is perfectly unnecessary. In constructing a new receptacle for manure on a sandy soil, it may be of service; but in an old place where the earth has once become saturated, it will not imbibe more; even on a sandy soil I have found, on removing a dung-heap situated on white sand, that for the depth of about one foot the sand had become perfectly black, but below it the separation was complete, and the sand remained pure and white.

After having removed one heap, and when commencing a new one, such vegetable substances as are most difficult of decomposition should be placed below, such as the leaves of trees, weeds, the stalks of plants, in short any thing that will best absorb the juices from the dung, and which after putrefaction will form good manure. In Switzerland, where great care is given to all the manipulations, dung made from straw litter is put in regular heaps, whilst the urine, after being collected as it issues from the stable in a trench provided for the purpose, is used separately. They form the outside of the heap of the most strawy part of the dung, and for this purpose they fold it with a fork in such a way that the dung is shut off from contact with the atmosphere. These dung-hills are elevated five or six feet, and arranged with the greatest care, so as to have the appearance of straw hives; because, on the outside nothing is seen but the folded straw, which is arranged with the most perfect uniformity. In dry weather they water these heaps, or pour over them the liquid from manure, in order that they may keep sufficiently moist for fermentation. The manure enclosed in these heaps, although deprived of a portion of the urine, becomes very excellent, and resembles a species of confection such as we have before stated is known under the name of black-butter. This subject is certainly well worth the

trouble of the experiment to determine the advantages of one method over the other.

There exists great difference of opinion as to the time when manure should be carted into the fields, and the state in which the manure should be. Most agricultural writers are of opinion that it should not be carted till it is entirely decomposed, when the tissue of the straw has lost its aggregation without being entirely destroyed, when it has much the consistence of butter or fat. Dung attains this state in a shorter or longer time, according to the degree of moisture and heat; in summer eight or ten weeks will be sufficient, whereas in winter it will require twenty or more. Dung which in this state has entirely lost its heat of fermentation, gives out no vapors except when being removed, at which time it has a fetid, rotten smell, and afterwards a smell of musk; its color is yellowish, which soon becomes brown by exposure to the air. When it is spread upon the land it assumes the appearance of burnt peat; it speedily absorbs moisture and falls to pieces, when it can be easily mingled in a uniform manner with the soil. Others give the preference to long dung not decomposed, and would have it carted immediately from the stable to the land.

If this dung has been subject to fermentation in the stable, where in winter, from the greater warmth, fermentation will be more rapid than in the dung-heap, it will resemble, in a greater or less degree, decomposed manure. Sometimes, also, fresh-made litter is carried into the field, and, as much as possible, buried in the soil; and it has been thought to produce more sensible effects than fermented dung. For heavy, tenacious soils, particularly where much manure is employed, this last process is doubtless the best; but great care must be taken to bury it well in the furrow, where the dung will of itself ferment and communicate its heat to the soil, whilst the straw will render it light and penetrable to the gases engendered. By means of the ammonia which it produces, it acts strongly upon the insoluble mould which these soils often contain, and produces several effects, of which one of the principal is to bring into action the nutritive portions of the soil which it before contained, and which effect decomposed manure produces in but a very imperfect degree. On the other hand, little benefit, and sometimes even inconvenience, is derived from undecomposed manure on light, poor lands which contain but little moisture, and consequently require all that could be communicated to them by the manure. Its bad effects are more particularly visible when it has been buried so shortly before seed-time as not to have time to become decomposed; if dry weather follows, the plant will suffer still more from the heat; and if wet weather ensues, the plants, it is true, will grow more rapidly, but they will be yellow and weak, and yield but an imperfect crop: they appear to have had too much hydrogen and not enough carbon. When the dung becomes dried up on the land, after having been covered up, it takes many years to reduce it into fertilizing earth, because it cannot enter into fermentation, but merely falls to pieces. This fact has given rise to the following maxim—that dung which produces no effect on the first crop will produce none on the second. It is, therefore, of the greatest consequence to cart and plow in the manure in a state suited to the wants of the soil.

My own experience, as well as theory, leads me to the conclusion, that it is very detrimental to remove manure whilst in a high state of fermentation; because at that period, an essential part of some of its most active properties would evaporate; but before strong fermentation has commenced, or after it has subsided, it appears to lose little by exposure to air, beyond what it regains in another manner.

There are visible advantages attending the spreading upon the land fresh strawy manure, and to leave it till the plowings of spring commence, taking care, however, that the water does not wash away the juices, and carry them beyond the field, but that it merely allows them to penetrate the earth.

This method of covering the soil during winter, renders it much more friable, and remarkably fertile. I have often seen the washed, but not rotten straw, thus left on the ground, removed to form fresh litter, and, nevertheless, the soil from which this straw has been collected appeared as perfectly manured as if all the straw had been decomposed. Meadows are often manured in this manner. I have so often seen the good effect of short or long dung thus spread over beans and peas, and left there during their growth, upon hot, light land, that I have

no doubt of its advantage on these two crops, particularly if they have been late sowed. But what is still more remarkable and difficult to explain, is that the following crops on land treated in this manner are also superior to those on which a larger quantity of decomposed manure has been plowed in. After harvest the stubble should immediately be broken up and covered with earth.

In 1808, I sowed trefoil with spring turnips upon some land which I afterwards strewed with fresh litter. In the autumn of 1809, the trefoil was broken up and sowed with rye, which, in the spring of 1810, was far superior to a neighboring field which had been manured in the summer upon the fallow. From many experiments tried by myself, as well as other agriculturists, it appears nearly beyond doubt that dung which has passed the highest state of fermentation loses nothing of its quality, but improves even during hot, dry weather. This assertion may appear incredible to those who have had no experience on the subject, and I was myself of the same opinion, till my attention was drawn to it by some practical farmers of Mecklenberg, who appeared to have proved the contrary. The strong smell occasioned by spreading manure, leads to the opinion that the evaporation from it must be very considerable; but when we consider that a few grains of musk will for years continue to perfume the atmosphere surrounding it, without sensibly diminishing its weight, it is permitted us to doubt whether the juices evaporated from the manure are very considerable; and if I may believe my own experience, it does not diminish its weight. There is no doubt that whilst in a moist state it undergoes several decompositions, because it absorbs oxygen, and gives out carbonic acid gas, which is again absorbed by the soil, and tends to amend it.

It appears, therefore, that there is no solid ground for objection to leaving the manure uncovered on the land for some time; but if the field lies on a declivity, there will be no risk of the juices being washed off the land by heavy rains.

The practice of leaving the manure on the land in small heaps, as it is unloaded from the carts, is very pernicious; and if it has not yet undergone fermentation, it will be attended with great loss, the wind carrying away the volatile parts, besides which the decomposition will be very irregular, the centre of the heap being entirely decomposed, whilst the exterior will be hardly affected. The most valuable portion of the juices will be absorbed by the soil immediately beneath the heap, rendering that part too rich, which the greatest care in spreading the manure cannot avoid; and the places where these heaps have been, will be marked by the rank growth of the crop, often for several years, whilst the surrounding parts present an impoverished appearance. It should, therefore, be made an invariable rule, that the manure should be spread as soon as deposited from the cart.

The proper time for carting manure varies much with the circumstances and economy of the farm. Where the triennial course with a fallow is followed, the time for carting is between the spring sowing and harvest; the dung, therefore, consists of that which has been collected during winter, which in those farms where the cattle are driven into the stable during the night, has, in addition, the nightsoil of the summer preceding, and of the same spring; the greatest part of this manure is, therefore, entirely decomposed; that which was last placed upon the manure heap being the only unfermented part. The careful agriculturist will, therefore, use those different sorts of manure separately: that which is fresh, he will apply to the damper and colder land, whilst the other portion will be used on those parts which are warmer and drier.

Winter manure is best suited for seed crops, whilst fresh litter is particularly adapted to potatoes, especially in clay soils, because it diminishes their tenacity and allows the plant to come in contact with the atmosphere; and in this case all the manure should be put in the row where the potato is planted, as we shall describe in its place. Other crops, and especially cabbages, do better with decomposed manure; indeed, on light land, this is essential to their success. Afterwards, the manure for beans and peas may be carted, and this can either be buried or spread over the soil. Part of the manure collected since the middle of summer may be used for the corn crops of autumn; though in this mode of cultivation these crops are never thoroughly manured, still an additional dressing is sometimes of benefit: at other times this part of the manure is carried on to the stubbles destined for fallow crops and the vegetables of the following spring.

There are various opinions as to the time when manure should be plowed into the fallows. Some think the plowing before the last, whilst others think this practice hurtful, inasmuch as the next plowing is very apt to bring the manure to the surface. For my own part, I am of opinion that it is decidedly better that it should be carted, so as to be buried by the first plowing, if this plowing does not take place till near the middle of summer. The method of leaving it to the last plowing is decidedly bad, and one of the principal causes for the failure of a crop; the manure can never be sufficiently mixed, but remains in lumps, which in some places heats too much, whilst in others it never gets decomposed, but remains nearly in the same state for years. This causes great inequality in the growth of the plants, some being drawn up in strong gross patches, which harbor insects and other vermin, and are very likely to be cut off in the winter; whilst others are weak and sickly. Some persons are prejudiced against the method of manuring before the last plowing, from the idea that the manure loses its juices, and favors the production of weeds. On the contrary, the seeds and roots of weeds are much better destroyed by this means; and the young plants buried by the plow increase the fecundity of the soil. An attentive examination of these facts will remove this prejudice, which has obtained amongst agriculturists from a want of having paid sufficient attention to the subject.

The proper distribution of manure is of such importance, that it demands the utmost care; a too abundant use of it is sometimes as detrimental as not sufficient, from its causing the crops to be laid; there is a maximum of quantity which should be employed, and to exceed which, is attended with great risk of spoiling the crop; it is impossible to fix this quantity, as it must vary with the nature of the soil. Wet clay land will require more manure than that which is hot, sandy, and calcareous; but heat has so considerable an effect on the crop, that when the temperature is very favorable to vegetation, the quantity of manure which, in ordinary seasons, would have been only sufficient, will cause the blade to be thick; it follows, therefore, that the difference between the harvest on rich and on poor lands, in these seasons, is less than it would have been in common or bad seasons; therefore, when manuring for an immediate crop, it is better to be rather below than above the maximum.

Where there is an abundance of manure, it is better not to manure immediately before wheat, but rather to manure for those crops which are never injured by a too profuse vegetation, such as most of the root crops, with the exception of potatoes, which may be over manured; also maize, cabbages, and such vetches as are cut for green fodder. These products absorb a sufficient portion of the juices from the manure, so that the following crop is never injured. The manure loses, in a greater or less degree, not only its heat and activity, but also its excess of hydrogen and azote, whilst it retains nearly all its carbon.

It is, however, more frequently necessary to pay attention to the opposite error, to see that those fields which require manure should at least have the full minimum quantity necessary for them; and it is a common rule in this case, to manure fully those principal fields on which we may the best rely for the harvest of grain and straw, even should the less important fields be passed over without manure. It is but too often that this rule has to be brought into practice, nevertheless we must guard against too great extension of it, by giving to the principal fields more than is necessary, and by this means retrenching from those which have the greatest want of it. It is true that the larger quantity lavished on the good land, may produce more immediate advantage, than if the overplus had been spread on poorer land; but the deprivation of manure on this land, will injure it to a much greater degree than will be compensated for by the more abundant crop on the good soil. Even if there should be a sufficiency of manure for each field, attention must be paid to the soil of each, if we wish to keep them all at the same point of cultivation.

To heavy clay lands a larger portion of manure must be given at a time, because they can bear it without risk of the crops being laid; whilst a smaller quantity, instead of producing an effect upon them, will probably be retarded in its fermentation, and will consequently remain in the state in which it was carried on. Upon a light, hot soil, the manure is quickly decomposed, and a very abundant supply may have a bad effect, in causing the crops either to fall or to scorch up. The lighter land is, the more it gains by being manured fre-

quently, but with small quantities at a time. It appears, however, an established fact, that in a number of years the two qualities of soil will require an equal proportion of manure.

Manure is generally reckoned by two or four-horse wagon-loads, or by one-horse cart-loads. With a good team a four-horse wagon-load is reckoned at 20 cwt; a two-horse load at 14 cwt.; but nothing is more indeterminate than the quantity of manure loaded into a wagon, as it depends, not only on the strength of the cattle, but on custom, the state of the roads, the distance, &c. The weight of the same manure will also vary according to whether it be damp or dry; when we wish to regulate the quantity of manure according to its weight, it will be necessary to weigh a load from time to time, so as to arrive at a pretty accurate judgment of the quantity carted: this operation can very easily be managed by a steel-yard, which will be found a very useful instrument in rural economy, 20 cwt. 2,000 lbs. (about one ton English) is a medium load for a four-horse wagon: but with a strong team is often carried in the summer time, and on good roads, 30 cwt. 3,000 lbs.*

There is still greater uncertainty in estimating manure according to bulk, because it depends so much on the degree of fermentation it has undergone. A cubic foot of long dung (very strawy dung) will weigh, perhaps, not more than 44 lbs.; whilst a cubic foot of rotten dung will weigh 56 or 58 lbs.; therefore, the quantity of juices contained in the manure has more reference to weight than to bulk.

To an acre of land, five, eight, or ten loads of one ton English, is often employed—the first would be called a light dressing, the second a good dressing, and the third a strong dressing; and would amount to about 8½ ounces upon a square foot.

Carrying the manure on to the land is an operation requiring much attention to the number of hands, of horses, and wagons, to be employed; so that there shall be no waiting for wagons on the part of those occupied in filling them; and also that the horses may be kept constantly employed, and ready to be yoked to the loaded wagon, as soon as they return with the empty one; it is impossible to say how many persons it is necessary to employ; but generally one man and a half, or a man and woman, to each team: but if the manure is in a condensed state, and the work goes on freely, this number will hardly be sufficient. The proportion of manure to be deposited in the field, can be better arrived at by separating the small heaps farther, or placing them nearer to one another, than by altering their bulk: a load of one ton will make about nine small heaps of 249 lbs. each. It will then be easy to determine the distance these heaps should be separated from each other, so as to give the required proportion per acre. Sometimes it is thought advisable to manure one part of a field more than another; the high parts will require more than the lower ground, particularly near the bottom of small hills, for the juices of the manure from these hills will of themselves pass to the lower ground surrounding them. It is not at all an uncommon thing to find the opposite carried into effect, from an idea that manure does little good upon hills; and the laborers are not unwilling to follow a plan which is attended with less trouble; it is, therefore, very requisite that a proper person should be appointed to see that the manure is deposited in the proper places, and to keep the teams to regularity in the distribution of their time.

When, independently of the laborers employed in carting, there are still other hands, it is best to employ them in spreading the manure, which will be done with more facility from its being less consolidated in the little heaps, which is a still farther motive for not leaving it on the land without spreading.

It is very essential to divide and scatter the dung well, there must therefore be no want of laborers for this purpose, and an intelligent man should be employed to follow the spreaders, and to separate any lumps of manure which they may have neglected.

It is also necessary to see that the manure is well buried by the plow, for which persons should be employed with forks and rakes to follow the plow, and to separate it in an equal manner in the furrows, when several plowings are to follow; it is not of so much consequence if a little litter is left uncovered, but

*And even 4,500. [*French Trans.*

great care should be taken that it does not collect in front of the plow, so as to form little masses in some parts, whilst other parts are deprived of it.

In some countries, it is the custom to mix the litter with all kinds of vegetable substances, or even with earth, and to leave it entirely to decompose; by this means, the liquid and volatile parts are better preserved; and if the addition which has been made consists of turf, these parts will be more intimately combined with the earth, and exercise their action upon it. This method causes several decompositions and combinations, which would not otherwise have been attained till a much later period. It is not even beyond probability that the water itself becomes, in part, decomposed, and enters into these combinations in a solid form.

Sometimes all the materials of which the compost is to be made are brought to the receptacle for manure, and there formed into a heap, or what is still better, the heap is made in the field where it is to be employed, which spares a double carting of the substances collected on the dung-hill.

There are two methods of forming these composts.

(*a*). The several matters of which they are composed are divided into different layers, and placed one above the other; at the bottom of the heap a bed of turf or of earth is placed, five or six feet larger on each side than the extended heap; then a layer, about a foot thick, of the freshest dung that is to be had; above this, another layer of turfts or earth; if there are any other matters capable of putrefaction, they are placed upon this bed, which is covered with another layer of dung, and so on, till it has arrived at a hight of five or six feet; it is then covered with another layer of earth. Quick-lime is often mixed with these composts, but the lime must not be in immediate contact with the dung, because it causes it to decompose too speedily, and to too great an extent. The lime is therefore placed between two layers of earth, or between the earth and any other substances which are difficult to decompose, such as the leaves of trees, and things of that description. When the sides of the bed of the dung-hill have become saturated with the liquor from the heaps, they are turned over, and spread upon the surface. The compost then heats, and fermentation commences, and it is left till this fermentation has subsided. When no more heat is felt in the interior of the heap, it is turned over, so that the part which was above becomes the bottom, and that which formed the sides is turned into the middle. Sometimes a fresh bed of earth is placed below the heap.

The heap when turned over is made long and narrow, resembling a roof, in order that it may be more exposed to the air; because it is thought that by this means it is increased in weight and quality, and it certainly causes a great increase of nitre. Those, therefore, who pay much attention to composts, turn them over very frequently, in order that a fresh surface may be constantly exposed to the air.

(*b*). Other agriculturists, particularly when they have a great variety of substances to be formed into manure, bring them all to the place where the dung-hill is to be made, and deposit them separately round it. The bed of earth for the bottom of the heap is then formed in the middle; the laborers then surround the heap, and each, with a shovel, throws the substances as they lie round it into the bed, by which means the whole mass is equally mixed throughout. Thus loam, earth, turfts of grass, moss, the leaves of trees, particularly of pine trees, saw-dust, and the remains of animal or vegetable matter, and very often, in addition to this, lime, ashes, soot, and fresh litter, are all incorporated, and the mixture wetted with the liquid which drains from the manure, or with urine. A larger or smaller quantity of lime is employed, according to the difficulty or facility with which the substances forming the mass can be decomposed; those substances containing acid are slow of putrefaction, and therefore, will require more lime; whilst, on the contrary, if there is much animal matter in the compost, lime may be spared. This dung-hill should, like the former, be allowed to remain quiet till the fermentation is past, when it should be turned over several times.

Those who disapprove of decomposing stable manures on a dung-hill, look upon this mixture as a useless increase of labor; this manure, they say, would be sufficiently mixed and incorporated with the earth by plowing, and it would have been accomplished in a far simpler and easier manner; besides, they allege that

the putrid fermentation of manure in the soil is very advantageous; and, as far as concerns cold argillaceous soils, they are quite correct. But what is a stronger objection to the general use of those composts is, that in them stable litter cannot be brought into use till the year following, which is of great importance where manure is not over abundant; for, independently of the products immediately drawn from the application of fresh dung, these products will again yield more manure before the compost will be ready for use.

It appears, therefore, that these composts should only be made where there is an abundance of manure, or where there is a considerable quantity of substances not easy of decomposition; and in these cases it will be found of great advantage as a sort of reserve, and will ensure the farmer a rich return for his labor.

Numerous experiments have tended to prove that the best way of using compost consists in spreading it over the soil without burying it. It is carried after the seed plowing, and spread abroad by being thrown from the wagon in shovelfuls by men stationed there; the seed is then sown in the ground, which is afterwards harrowed, or receives a very light plowing. The compost may even be spread over the ground after the sowings have taken place, if such a proceeding be deemed expedient. It is sometimes spread over autumnal corn, but is more frequently reserved for the spring cereals when their vegetation has commenced. This method of manuring is productive of the most astonishing effects, while a very small portion of the compost is actually used. The testimony of persons who have themselves practiced it, as well as the high estimation in which it is held throughout whole kingdoms, serve to attest its utility and the benefits derived from it. In Hertford, a large county of England, this practice has been adopted from time immemorial; indeed, they scarcely use any other species of manure. The English term this mode of manuring "top-dressing." The system of cultivation in the above-mentioned county is not otherwise distinguished by any peculiarity, yet the crops are remarkably fine, and the agriculturists there declare that they are never known to fail. These men attribute an almost magical influence to the practice of spreading compost over the cereals during their vegetation. According to them, when wheat has been partially destroyed by the severity of winter, or barely injured by frost, drouth, or humidity, becomes diseased, and can scarcely be said to vegetate, the compost produces the most marvelous effects as soon as it is applied. They assert that the plants may almost be seen to renovate and regain their verdure. This beneficial effect of compost is confirmed by the unequivocal testimony of almost every writer on English Agriculture.

It is, therefore, evident that not only actual advantages but also security against evil is to be derived from the possession of an active manure of this nature, and without any sensible diminution of that dung which is absolutely necessary to meet the wants of the current year.

In many writings an innumerable variety of directions for compounding this mixture are to be found, in which the exact weight and measure of each separate substance is given with all the formality of a medical prescription. But this is downright pedantry; all that can be said on the subject resolves itself into the following precept: "Collect every vegetable, animal and mineral substance which you have at your disposal, taking care, however, that the latter consist of such matters as are proper for the purpose: mix them well together, add a little quick-lime and as much earth as will absorb the gases evolved by these various substances; allow them all to remain in a heap until they are thoroughly fermented, and then mix or stir them repeatedly until they are transformed into an homogeneous mass."

Where there is a scarcity of straw, various vegetable substances are used for the purpose of absorbing and retaining the excrementitious matters, and forming a dry bed for the cattle, as well as for increasing the quantity of the manure; because the vegetable substances devoted to this purpose are much sooner induced to enter into putrefaction when mingled and saturated with animal excrements than if left to themselves. The propriety of using, and the selection to be made of these varieties of litter, therefore, depend as well on the qualities which render them fit to furnish the cattle with a dry, healthy bed, as upon the greater or less disposition which they have to enter into decomposition.

The litter in most general use, after straw, is the *leaves of trees*, and espe-

cially of those belonging to the family of pines. The forests of those countries in which there is almost always a scarcity of straw are chiefly composed of pines or of trees of that kind, consequently an abundance of leaves can be collected from the ground and intermingled with mosses. When these leaves are intermixed with the excrements of animals, they become decomposed much sooner than they otherwise would be; nevertheless they retard the fermentation of the manure, which must then be allowed to remain in the heap much longer than would be necessary if the excrements of the cattle were mixed with straw only. When once the decomposition has taken place, the dung, so far from being inferior to that which is simply composed of straw and excrements, appears to be in no small degree superior to it, because the pine-tree leaves contain a far greater proportion of nutritive juices than the straw.

Oak leaves are not easily decomposed, and contain an astringent matter which is highly injurious to vegetation so long as the leaf remains undecomposed. Manure, therefore, which is partly composed of oak leaves must not be removed from the heap for a considerable period, if we would derive actual benefit from the use of it. If it is placed in the ground before it is thoroughly fermented, its leaves remain there for a long time before they rot, and may prove rather prejudicial than otherwise, especially to light soils.

The leaves of *beech*, *walnut*, and *chestnut trees*, while yet green, certainly appear to be even more injurious to vegetation than those of the oak, since little or no grass ever grows under these trees; but when mixed with dung, they soon lose their baneful properties and rapidly decompose. Myself and several brother agriculturists have seen much more beneficial effects resulting from the use of manure made with the leaves of beech, walnut and chestnut trees than from that which contained oak leaves.

The leaves of the *alder*, *willow*, and *poplar* also seem to have the property of being rapidly decomposed; but they possess little consistence, and tend very slightly to increase the volume of the excrements which they receive. There are many districts and agricultural undertakings in which these leaves are reckoned upon as an essential part of the litter, because nearly or quite the whole of the straw is reserved for winter fodder for the cattle; and on account of the general arrangement of things, it would be absolutely impossible to do without this additional litter. But it is well known that woods and forests are in no small degree injured by this practice, and the harm done to the trees far surpasses the scanty profit derived from this false economy. The obligation of furnishing leaves for this purpose has become an exceedingly burdensome tax on the proprietors of parks, forests, or other wood lands, and one which, it is to be feared, from the existing system of cultivation, there will be considerable difficulty in abolishing. When the owner of the forest himself makes use of the privilege, and uses it with moderation and discernment, there cannot be a doubt that he will occasionally derive great and real benefits from it; but those who hold this right over the property of another, are seldom very particular as to the manner in which they exercise it.

In countries where *heath* and *broom* are very plentiful, these plants are used for litter, when the substances which we have been describing are all exhausted. Sometimes the heath is mown or cut, while at others it is torn up from the soil with a species of hoe adapted for the purpose; and thus, not only the plant itself, but also that portion of the mould which clings to its roots, is taken away. Although this plant can hardly be said to become decomposed in a course of a year, nevertheless the animal excrements with which it is mixed, render it so soft and deprive it so completely of the astringent matter which it contains, that when transported to the land it soon becomes perfectly decomposed and divided. In a part of the principality of Luneburg, of the bishopric of Breme, and in Pomerania, many persons regard this plant as so indispensable to rural economy, that they hesitate to extirpate it or to bring those spots which are overrun with it into cultivation, because they cannot conceive the possibility of doing without this plant in the formation of their manure; in fact, it will be impossible to do without it so long as the present arrangement of their rural economy remains in force. Many agriculturists who hold the right of gathering heath on the land of others, and who rigidly exact that right to the uttermost, are enabled to maintain land of the most inferior quality in a wonderful state of fertility.

But as this plant grows slowly, especially when the surface of the soil is torn up with it, it will probably require a hundred acres of heath to maintain an acre of arable land in good condition; this practice, therefore, can only be carried into effect on small estates, surrounded by an immense extent of uncultivated land. If the heath must be gathered from any considerable distance, a great deal of time will be lost, and the laborers and teams will be employed in this operation during a considerable portion of the year. Frequently it is actually more difficult to procure sufficient heath to ameliorate an acre of land than it would have been to cover the same extent with marl or mould. Nevertheless, few appear startled by the expenses attendant on the former proceeding, while they would pause ere they ventured to adopt the latter; so much do prejudice and the force of habit govern our actions.

The agriculturists are not contented with spreading the heath under the cattle, but they also mix with the manure the portions of earth and turf dragged up at the same time, and form a heap of these substances in the field, which they suffer to remain untouched until the whole mass is thoroughly decomposed. When this manure is mixed with a small quantity of animal excrements and is thoroughly consumed, a small portion of it is spread over the fields, where it will often produce very fine crops of rye and buckwheat. As very few weeds shoot up from it, the land does not require a fallow, but is capable of bearing six or seven consecutive crops, which, however, progressively decline in value. Persons who are not aware of all the difficulties attendant on the acquisition of this manure, regard it as in the highest degree desirable and beneficial, and heath lands as of the greatest possible utility. The celebrated De Luc, in his travels through these countries, considered this practice as a weighty reason for deciding against the division and enclosure of commons and uncultivated lands. There can be no doubt that there are cases in which heath may be used as litter with the greatest possible advantage. This is especially the case in sheep-folds, where this plant is readily decomposed by the action of the excrements of these animals.

Many other vegetable substances—as reeds, rushes, aquatic plants, the genet or way-thorn, moss, fern, &c.—may be used as litter when nothing else can be obtained. Some of them, and especially those which when burned yield a great deal of potass, produce a very fertilizing mould. The more green and succulent they are when placed under the cattle to receive the dung, the more rapidly do they decompose; but, when in this state, they do not afford so wholesome a bed for the cattle. After having become dry, these plants are not decomposed without difficulty; and, therefore, the manure of which they form a part must be suffered to remain on the heap for a greater length of time. Reeds are not easily decomposed unless they have been on the roof of some building for a considerable period, and become softened by exposure to the atmosphere; they then appear to produce a particularly good manure.

The sweepings of barns should not be mixed with manure without the greatest circumspection being exercised, if we would avoid the danger of infesting the land with weeds. The vitality of the seeds contained in these sweepings is not entirely destroyed even by the process of fermentation; the best way of making use of these matters is to mix them with the manure intended for the meadow land.

In low, damp situations, a substance similar to moss is frequently found, filled with all sorts of aquatic plants, and which may be advantageously substituted for peat. When this substance is dried, it is peculiarly adapted for the formation of litter, because it is promptly decomposed by the dung, has a strong tendency to absorb moisture, and produces a valuable kind of manure. But it ought not to be used while any other kind of litter can be procured, because it might better be transported to the fields in its natural state, where, after having been mixed with straw manure, it will be found to decompose rapidly and thoroughly.

Sometimes, and especially in sheep-folds, turf or peat is used for litter, when it is of a light texture. We shall have to treat of this subject, and of the properties of this substance, when speaking of manures in general.

Many agricultural writers have advised the use of earth as litter. Turfs taken from places where they are altogether useless may thus be converted into mould, and afford an excellent manure; and there is no doubt that this substance is con-

siderably ameliorated by its transit through the stable, where it absorbs the urine and superabundant humidity of the excrements in general. But pure earth can never actually become manure; it can only absorb the dung and a portion of the urine. Besides its being a very difficult matter to keep the cattle dry on such a bed, this practice is productive of much heavy labor and cartage; as the earth has, in the first place, to be dug up and brought to the stable or cow-house, in order to be thrown underneath the cattle, and subsequently taken away and transported to the fields. I do not think that I ever saw this practice carried into effect, nor am I aware that it exists any where, excepting in those English counties, Norfolk and Suffolk, where the sand thrown up by the sea, and which is for the most part composed of shells and lime, is carted while dry, and conveyed to the stables to be employed as litter; this is, however, only the case in towns. The dung which is mingled with this species of sand ought to be very active.

The transporting of earth, and especially marl, to the dung pits or steads, and placing it there for the purpose of saturating it with dung-water, is quite another matter. An excavation in the form of a basin is made in the middle of the heap, into which the fluid is poured; and, in order to facilitate the introduction of the liquid or dung-water, holes, extending to this basin, are bored in the heap, with a pole or bar of iron, in different places. When the earth is sufficiently impregnated with this fluid, it is conveyed to the fields. Sometimes the dung heap is surrounded with a wall of earth, in the form of an enclosure or embankment, on which a little canal or gutter is hollowed, to receive the superabundant moisture of the heap. When the wall of earth has remained in this state for several years, and has consequently absorbed a great quantity of the emanations arising from the yards in which the cattle are enclosed, it is conveyed to the fields, where it produces wonderful effects. But, previously to undertaking this operation, however beneficial and useful it may be in itself, the expenses which will be occasioned by the carrying of the earth to the farm yards, and thence again to the fields, as well as the labor attendant on the watering of it, should be calculated.

However general and advantageous the custom may be of making use of straw and other substances for the purpose of collecting the excrements of the animals, and forming a litter for the cattle, it is not universal. Cattle are not unfrequently kept in stables and cow-houses, both during winter and summer, without any litter, especially in countries and farms where breeding and fattening of cattle form the principal aim and object of the undertaking. The arrangement of stables devoted to this practice varies considerably; in general, the floor on which the cattle are stalled is formed of boards, which incline slightly from the head to the hinder parts of the animals. At the edge of this flooring, and behind the animals, is a gutter or conduit of masonry or plaster, into which all the excrementitious matters fall, or are swept with a broom, as soon as they are voided. There are often pumps or water-courses in these stables, which are immediately used to wash away the excrements. In order that the animals may not soil themselves, or become dirty, care is taken to keep their tails suspended; this is done by means of a fine cord, which, passing over a pulley attached to the ceiling, has a weight at its opposite extremity proportionable to the weight of the tail, which is thus kept from falling on the floor and becoming fouled, and, at the same time, is not drawn up too roughly. Or, the cattle are lodged on a plaster floor, pierced with holes communicating with a reservoir of masonry or cement, in order that they may be kept dry. The urine and liquid portion of the manure collect in these reservoirs, and thence flow out through gutters into the tanks or pits intended for their reception. That portion of the excrements which retains its consistence is thrown behind the animals against the wall; and so much care is taken each time to cleanse the place, that it is as neat and clean as the floor of a room. This practice not only contributes to the health of the animals, but also to the quality of their milk—specially as, wherever it is pursued, they are carefully curried down and brushed.

In other undertakings, recourse has been had to a far more simple arrangement, but one that is not so beneficial to the cattle. Then the buildings destined for the animals are so narrow that they are obliged to draw up their hind legs in a manner wholly contrary to nature, in order to be able to face the manger. Behind them is an excavation of a foot and a half, or two feet deep, and into this

the excrements and the urine of the animals fall, provided that they are not standing aslant. They must, therefore, be tied very close together, in order to compel them to face the manger exactly, both while standing up and lying down; which they certainly would not do if they had the power of moving either to one side or to the other. The cattle must be well accustomed to this fashion, or their legs will inevitably slide backwards and fall into the excavation; and thus the legs and thighs will be liable to excoriation and injury.

Whatever may be the difference which exists between these two methods of stalling cattle, it is not in that alone that the management of the manure varies. The large excrements are either carried out of the stable, and, having been mixed with straw, are made into regular heaps, care being taken that the pure dung shall be in the centre, and that which is mingled with straw on the outside, and these heaps are occasionally watered with dung-water; or else, a slight litter of straw is occasionally strewed under the cattle; a little water is pumped up and added to the excrements which the gutter or excavation already contains; the straw is thrown into this gutter by a fork, and there worked backwards and forwards in order to make it take up as much of the large excrements as possible, and then conveyed to the dung-heap on the outside of the stables. More water is subsequently pumped up and carefully mixed with those excrementitious matters which remain in the gutter, until the whole forms an equal and flowing liquid, which is then propelled through the open gutters to the tanks or reservoirs intended for the reception of the liquid manure.

By these means the large excrements mingled with straw are kept entirely separate from the liquid manure, and either one or the other is made use of, as circumstances require.

It is necessary to have several tanks or reservoirs for the reception of the liquid manure, and also that the canals should be constructed so as to fill first one and then another. In fact, before this fluid can be used with any degree of advantage, it must have undergone a species of fermentation or putrefaction; until this putrefaction has been brought about, it must be covered up and kept from contact with the open air, and only stirred now and then. These tanks or reservoirs are successively emptied when the fluid which they contain has reached the proper degree of fermentation, and are then filled again.

Very great commendation is bestowed on this practice, and on the value and quality of the manure which it produces; but I cannot help considering that a great deal of exaggeration must be mingled with it. It is asserted that with the assistance of the straw as much dung is obtained as there would have been if the animals had been littered down in the usual way, and that this dung is rendered more active and fertilizing by the pains which are taken to collect it; and it is farther asserted that they have liquid manure in addition, which, from the effect which it produces, is equally as valuable as the concrete dung, if not more so; and that, consequently, this practice produces twice if not thrice as much manure as would have been obtained under the ordinary course of proceeding. This seems to me to be such an absolute contradiction, that I cannot allow myself to be convinced of the truth of these assertions,* until well authenticated comparative experiments shall have attested their correctness. I do not mean to deny the fact that a much greater quantity of nutritive juices may be produced by this than by the ordinary mode of proceeding, because more complete decomposition and new combinations of elementary matters may thus be brought about. General experience has proved beyond a shadow of doubt, that liquid manure produces a very beneficial effect, especially on sandy soils, to which it restores some portion of that consistency of which they have been deprived by reïterated plowings and ameliorations of strawy dung. All kinds of animal and vegetable refuse are thrown into the tanks destined for the reception of the liquid manure, and especially human urine.

* The actual advantages arising from the use of animal excrements in a liquid form as manure, consists in that assimilation to the organs of plants with these excrements have undergone during the fermentation of the liquid, and in the greater degree of facility which a liquid form gives them of coming into immediate contact with the plants and being immediately absorbed and diffused throughout their substance, and thus re-producing vegetable matter promptly. There is not a doubt that a given quanity of excrements may, under this form, yield double if not quadruple as much produce as they would have done had the excrements been employed in a concrete form. This practice may, therefore, prove exceedingly advantageous in rural undertakings which do not possess a sufficiency of manure, supposing that the texture of the soil is light enough to admit of the constant use of liquid manure without any bad effects being produced. [French Trans.

Although it is far from being my intention to dispute the advantages attendant on this practice, yet I think that previous to the adoption of it, it would be as well to be assured that these advantages will repay all the labor and care which are requisite. In order to effect this end, it should be brought fairly into comparison with our ordinary course of proceeding, in which also everything should be so arranged that no particle shall be wasted. With us, as soon as the dung possesses more humidity than it can retain, the liquid that oozes out is collected and applied: but if, as too often happens, the situation of the dung-steads or heaps is not carefully arranged, and this fluid is allowed to drain away without being collected, then there can be no doubt that an essential portion of the manure is lost, particularly if the cattle have been fed on green meat, or on very succulent fodder. Reservoirs or tanks for the reception of those liquid portions of the manure which, having passed through the heap, ooze out, and would drain away and be wasted if not collected, are necessary appendages to every farm yard.

The care which must be bestowed on liquid manures, and the difficulty of transporting them, are neither so great nor so laborious as many persons suppose. The liquid can easily be drawn up from the stone or cement tank which contains it by means of a pump, and transferred to large vats or casks constructed for the purpose. These vessels are then placed in wagons for the purpose of being carried to the fields; at the back part of them a hole or opening is made, to which is attached a box or board,* into which or on which the liquid falls, and is thus diffused in an equal manner over the land as the cart moves onward. The cart is driven faster or slower, according as it is deemed advisable to manure the soil more or less abundantly.

The liquid manures are specially devoted to those crops which will bear rich ameliorations, which are prompt and energetic in their action, as the wild cabbage. Some agriculturists reserve them for clovers and other artificial meadows, or for natural pastures. With regard to cereals, they may easily be rendered too thick if the soil on which they are sown is ameliorated with manure of this kind, unless, indeed, the liquid is very weak or has been diluted by an admixture of water. Liquid manures are never so advantageous as when applied to sandy soils, which they render tolerably consistent and more adapted for the retention of moisture. In soils of a mediocre quality, liquid manure and dung are employed alternately; but the use of liquid manure will never replace that of dung on tenacious and argillaceous land.

Liquid manure can never be so advantageously employed as in restoring the requisite degree of moisture to dung which has become so dry as to cease to ferment. Wherever this is the case, the heap should immediately be watered by this fluid.

Lastly, in enumerating all the various animal manures, we must not omit to mention that arising from the folding or cotting of sheep or cattle on arable land. The animals are turned during the night into a fold enclosed by lathes, hurdles, or twigs. By these means the excrements, and even the vapors which emanate from their bodies, are concentrated within the space assigned to them; and in order that these substances may be more thoroughly incorporated with the soil, the land generally receives a slight plowing before the cattle are enclosed on it.

This practice is usually followed only with sheep. A somewhat similar proceeding has, however, been occasionally adopted with the other kinds of cattle. Oxen which have been put up to fatten are enclosed in a certain space of ground in the neighborhood of the most abundant pasturage, or of those divisions of fodder which are destined for their consumption; straw is littered over these enclosures, which mixes with the excrements voided by the cattle and serves to collect them. By these means the dung is turned to great account; whereas, if it were voided over the pasturage, it would be rather injurious than otherwise, and in a great measure, wasted. Some persons have even gone so far as to establish an enclosure of this nature for geese, and profess to have derived considerable advantage from it. These things are, however, of rare occurrence, the practice is in general solely confined to sheep; and opinions are yet very much divided with respect to the advantages and disadvantages that result from folding.

* Several well constructed carts for the distribution of liquid manure have been invented by our most experienced agricultural implement makers.

It still remains a question whether this close confinement of sheep be injurious to their health and fleece. It is only the strongest and most vigorous breeds that can support it. In England there are many fine long-wooled breeds to which it proves fatal; although the same animals when allowed their liberty, and suffered to run in the open air are vigorous and healthy both in summer and winter.

Although the sheep of our country, and even those of pure Spanish breeds, can support this system without being killed by it, nevertheless they thrive better when allowed to run at liberty during the night, or sheltered beneath a roof from the inclemency of the weather: this practice is very injurious to lambs.*

Independent of the difference in the health of the animals, folding at night in littered yards combines all the advantages of folding on arable land without any of its disadvantages; the excrements there become mixed with the straw, and produce a manure which, if not quite as active as that yielded by the fold or pen, is more durable in its effects.

On the other hand, the pen or fold has this actual advantage, it saves the labor and expense of carrying the manure; and the farther the fields are removed from the farm buildings, the greater is the advantage derived, especially when the roads which lead to them are bad. Hence arises one great inducement to the agriculturist to have recourse to this practice, especially in mountainous countries, and on hill farms. Another, is the want of straw and other substances which might be used as litter.

Thus, then, it is evident that in this, as in many other cases, locality and convenience lead persons to adopt one course of proceeding rather than another.

English agriculturists also allege another objection to this system. They assert that sheep-pasture lands rapidly deteriorate when deprived of the excrements voided by these animals during the night, and improve as visibly where the contrary course is pursued; and bring forward in support of that assertion numerous incontestible experiments, which tend to prove that in the former case the number of sheep which they will keep is annually decreased, while under the latter they are capable of supporting a larger number every year, and become progressively ameliorated; that, lastly, the difference between the fertility of sheep pastures which are allowed to receive all the dung voided by the animals during the night and those which are deprived of it, is very striking.

In reply to this objection, others have urged that if sheep were allowed the liberty of a considerable extent of pasturage during the night, they would still huddle as closely as possible together; and consequently, instead of diffusing their excrements over the field, would void them all in one place, where this accumulation would tend to injure rather than ameliorate the pasture. And they likewise state that the sheep invariably congregate as nearly as possible in the same place every night; but I have never found this observation in the works of any English agricultural writer, even of those who are most favorable to the practice of folding sheep. In my opinion, sheep which are turned into pastures surrounded by hedges, and which are not driven together by the shepherds or their dogs, will never acquire this habit.

The following regulations must be attended to in folding sheep:

1. The fold or pen must never be made larger than is absolutely necessary: sheep have a natural propensity to crowd as closely together as possible. If, therefore, the enclosure into which they are turned is larger than there is any absolute necessity for it to be, one portion of the land will be thoroughly ameliorated, while another will be imperfectly manured. Not more than ten or twelve square feet should be allowed to each animal, if we would have them manure thoroughly the space assigned to them.

2. The hurdles of which the pen or fold is composed ought not to exceed ten or twelve feet in length, in order that the shepherd may be able to carry them from place to place and fix them in the ground. The proportionate number of

* The effect of warmth upon the consumption of food by animals, although by far too little understood, is also an examination fraught with instruction to the farmer. In an experiment of Lord Ducie's, at Whitfield, one hundred sheep were folded by tens in pens, each pen possessing a covered shed. From the 10th of October to the 10th of March each sheep consumed, on an average, 20 lbs. of Swedes daily. Another one hundred were folded in pens of a similar size, but without sheds attached; they were kept during the same time, and their daily consumption of Swedes amounted to 25 lbs. each. And yet the sheep which enjoyed the protection of the sheds increased in weight 3 lbs. each more than those left unprotected.

[*Jour. Roy. Ag. S.*, vol. iv., pp. 222—230, vol. i., pp. 140–147.

these hurdles need not be increased in exact ratio with an increase in the flock of sheep. If we suppose each hurdle to be ten feet long, and that each sheep ought to be allowed a space of ten feet in extent, a flock of two hundred animals will require eighteen hurdles; and a flock of three hundred only twenty hurdles, if the pen is constructed in the form of a square. Besides, a small flock requires equally as many attendants as a large one, and consequently the expense of each separate animal is diminished in proportion as the aggregate number is increased. On this account, it is seldom deemed advisable to fold less than three hundred sheep.

The comparative richness of the amelioration bestowed on land by the practice of folding, varies considerably. Some have endeavored to define it according to the greater or less extent of the space on which the animals are enclosed; others, by the time which they are suffered to remain on one spot. But these data are very unsatisfactory, because the quantity of excrements voided by the sheep must depend entirely upon that of the food which they have consumed; and their value will be in proportion to its fattening quality. If the pasturage is abundant a given number of sheep will manure the spot on which they are enclosed as effectually in one night as they could do in two or three if kept upon scanty pastures. Every one must be struck with the truth of this observation.

Folding is divided into three classes, which are designated "complete-folding," "half-folding," and "extra-folding." If the pasturage be of a tolerable quality, the folding is said to be complete when six hundred sheep are penned on an acre of land for three nights; or, what amounts to the same thing, when one thousand eight hundred sheep are folded on an acre for one night. A slight or half-folding is said to have taken place when one thousand two hundred sheep have passed the night on an acre of land; and the ground is said to have received the benefit of an extra-folding when the same extent of space has been occupied by two thousand four hundred sheep.

Even supposing the pasturage to be always equally good, the length of the nights will cause no slight difference in the effects of the folding. When the nights are shortest, the animals are not in the fold more than eight hours; whereas, during the long nights, they remain there for twelve hours, if not more. To this consideration must be added another, namely, that in most agricultural undertakings, sheep, in general, receive but a scanty pasturage during the term of the short nights; and that they are much better fed in the spring, when they are depastured on the meadow or fallow lands previous to their being broken up, or in the autumn, when they are turned on the stubble fields. In order to compensate for this inequality, some persons have divided the long nights into two equal portions, and have caused the sheep to spend half of the time in one place and half in another. Where the shepherds are not accustomed to this mode of proceeding, the best plan will be to contract the limits of the fold during the short nights, and thus make up the difference by diminishing the number of hurdles, or arranging them so as to enclose a smaller space. A similar number of hurdles will embrace a much greater circumference when set up in the form of an exact square, than they would do if made into a long square. Twenty hurdles, each twelve feet long, if set up in a square form, will enclose twenty-five perches; but if the same number were arranged so that there should be eight on each side and only two at each end, they would not then enclose more than sixteen perches. The Count de Powdewils has drawn up a table for regulating the proportionate space according to the length of the nights. It will be found in vol. i. "Annals of Agriculture," and clearly indicates the intensity of the manuring which will be derived from the form given to the fold and the arrangement of the hurdles.

Sheep are generally driven into the fold at sunset, and not let out again until the dew is evaporated, because that vapor would be very likely to prove injurious to them on account of the voracity with which they then eat. Before they are let out, they are moved about in the fold in order that they may empty themselves completely, and that no portion of their excrements may be lost on the road.

The kind of manure produced by folding is easily decomposed, and, consequently, acts with great promptitude and energy. It produces a peculiarly sensible effect on the first crop; but its effect on the second is very slight; and, where only a slight folding has taken place, it is not felt at all. It is only an ex-

tra folding, when two thousand four hundred sheep have been enclosed on an acre of land, that is capable of producing effects which endure until the third crop; especially if, immediately after the folding, rape, or some other produce of the same or a similar nature, is sown instead of grain crops. It is thus that the greatest amount of profit can be derived from this practice. Should such a course not be adopted, there will be every reason to fear that the cereals will be laid—an inconvenience which is too often induced by ameliorations of this nature.

In general, when the farmer wishes to ameliorate his land very considerably for the corn crops, he first manures slightly with stable manure; and then, after having buried that by plowing, he folds a few sheep there.

Corn crops succeeding the folding of sheep, especially of a large flock, acquire bad qualities, which cause the grain to be rejected by bakers, brewers, and distillers of brandy. We shall have occasion to return to this subject hereafter.

The soil is usually plowed before sheep are folded on it; and as soon as the folding has taken place, they hasten to bury the manure thus deposited on the ground, by a superficial plowing. Although this proceeding is universally adopted, I have had my doubts as to the eligibility of it, since I have learned several experiments being made by agricultural friends of mine, who assert that they have seen the most beneficial effects resulting from folding, when the manure was suffered to remain on the surface of the soil for a considerable period.—There is no doubt that great advantages have been derived from folding sheep on land after the seed was sown in it. I have seen wonderful effects resulting from an amelioration of this nature bestowed on a field in which potatoes had been planted.

The practice of folding is sometimes adopted for the purpose of manuring hilly or mountainous pasture lands, or artificial meadows; and with great success, especially where these places are difficult of access, and it is almost impossible to transport manure to them in the ordinary way.

Many persons who are prejudiced against immediate folding, and who have a superabundance of straw for litter, and who wish to improve distant or hilly parts of their farm with sheep-dung, make movable enclosures in the neighborhood of these spots, which they strew with an abundance of litter, and then drive the sheep into them. Sometimes the animals are only confined in these folds at night; at other times they are kept there during the day also, especially when these folds are sheltered by trees. Thus, they have the dung made in immediate proximity to the fields on which they wish to use it, and an immensity of labor is spared, for the carriage of the straw is far less expensive than that of the dung. In these movable folds, the sheep may be allowed more room, and the straw affords them a more healthy bed than would be furnished by the damp ground.

As all animal substances form very active manures, the fertility of the soil and the amount of its products will be very sensibly augmented, if not only the excrements of animals, but also the bodies of those animals which die, and all the offal from those which are slaughtered, are carefully preserved and used as manures; and no portion, however small, of these manures is suffered to be lost or taken away from the great and universal circulation of Nature.

Animal bodies, when deprived of vitality, form a peculiarly active manure.—If these are collected together in trenches, or enclosures walled round, covered with quick-lime, mixed with earth, and subsequently, when they have lost their putrid and offensive smell, which is soon carried off by the lime, the whole mixture be well stirred and mingled together, an exceedingly active manure will be obtained. But if, on the contrary, these substances are suffered to decompose in the open air, buried deeply in the ground, or thrown into the water, they are withdrawn from the circulation of organic matter, and a considerable portion of the elements of life is thus lost.

Even bones are softened by the admixture of quick-lime, and may then be powdered without difficulty. After this preparation they produce wonderful effects on land.

On the sea-coast, fish are not unfrequently used as manure; and also occasionally at the mouth of large rivers, as is the case when an enormous quantity of herrings is thrown on the shores of the Elbe. But these fishes must be covered with quick-lime, and subsequently mixed with earth, if we would derive that amount of benefit from them which they are capable of producing. Experience

testifies that this mixture is productive of wonderful effects when spread over the sowings; but that when the fish are scattered over the soil and buried before they are thoroughly decomposed, they are positively injurious in the first year, and productive of little advantage in the second. The same may be observed with regard to rancid oil of herrings, which is sometimes used as a manure.—When undecomposed, it is, in common with all other oleaginous substances, prejudicial to vegetation; but when its decomposition has been effected by means of lime or alkalies, it becomes a very active manure, as numerous experiments tend to prove.

Horn must also be included in the list of highly efficacious animal manures.—It contains a larger quantity of decomposable animal matter than bone, and is decomposed with less difficulty, and is almost entirely dissolved in nitrogen, hydrogen, carbonic acid, phosphorus, and sulphate of lime, and then apparently enters into divers combinations with them in various proportions, producing thereby exceedingly fertilizing matters. The shavings or clippings of horn, or the residue left by turners, comb-makers, &c. are most frequently used for manuring land. The most minute portions are the first to become decomposed; but, although their effect is most sensible, it does not last more than a year. But this effect may easily become so great as to cause the chief part of the cereals to be laid; besides, on account of this excess of fertility, they are longer in arriving at maturity: the grain does not ripen so soon; the ears of corn are more subject to rust; the grain itself contains less farina; and, in short, the crop has all the defects of cereals sown on land which has been ameliorated by the folding of sheep—possibly because both contain too great a proportion of nitrogen. It is, therefore, better to ameliorate those soils with horn which are intended for the production of crops which are not liable to suffer from an excess of manure. If some few larger pieces are found among the shavings, or if hoofs are chopped and mixed with them, the decomposition goes on more slowly. These matters do not produce much effect in the first year; but when once the effect is produced, it is more durable. English agriculturists consider that from five to six hundred pounds of this substance is a sufficiently rich amendment for an acre of land. I have used twenty-four bushels of these shavings on that extent of land. A bushel weighs from twenty-four to thirty-two pounds, according as it is composed of shavings or large pieces. The best plan is to determine the quantity by measure rather than by weight, because the thin shavings weigh less than the clippings, while their effect is more prompt and energetic.

The hoofs of animals, of which butchers frequently have an immense quantity by them, should be chopped into small pieces previous to being spread over the land; but this is by no means an easy task, unless the hoof has been previously softened by being steeped in water, to which a little lime and ashes have been added, for a considerable time; but hoofs may be used whole with considerable advantage for the purpose of ameliorating meadows. Where this is done, holes are made in the ground, about a foot and a half or two feet apart, and into each of these is put the hoof of an ox, full of water. An abundance of grass shoots up round this hoof on the first year; on the second the amelioration extends yet farther; and on the third year, the hoof being totally dissolved, the whole of the meadow is ameliorated.

The refuse of the shambles, consisting of blood, hair, and all kinds of filth, likewise forms an excellent manure: mixed with earth, and used in small quantities, these substances produce prompt and energetic effects. It would be al most extravagant to make use of them or bury them as we should other manures, as they can be employed with so much more advantage in the form of compost.

The same may be observed with respect to the offal of tan-yards. I here, of course, allude to the animal portions, and not to the tan. This is also a very active species of manure, and one which should be employed in the formation of compost, and spread over the land sparingly.

The hair and wool of animals is composed of the same constituent parts as horn, but these substances do not decompose so rapidly, at least until they have been mixed with a little lime. In England, woolen rags, feathers, and old hats are carefully collected and sold as manure. They are thrown into trenches, sprinkled with quick-lime, and then left to decompose; and, subsequently, the matter thus formed is mixed with the soil. It is an undeniable fact, that if

nothing which could by possibility tend to accelerate or enrich vegetation were wasted or suffered to be lost, an immense increase of products would be the result.

Shoes and old leather are not very easily decomposed by the simple action of the atmospheric air, but if mixed with a little quick-lime they speedily enter into a state of decomposition, and are transformed into a mucilaginous substance. The residue of the grease-tubs of tallow-chandlers, when not used for the purpose of making soap, forms an excellent manure, but one which ought only to be applied in the form of compost.

The scum taken from the boilers of sugar-bakers, and the residue of these manufactures, consisting, for the most part, of blood, mucilage, and lime, must not be omitted in the list of animal manures. In rural undertakings, in the neighborhood of large towns, an abundance of this substance can always be procured; and it is a general opinion that there is no variety of manure which can surpass it in the effects which it produces, or which goes so far.

All the last-mentioned species of animal manures are only within the reach of those agriculturists whose farms or estates are situated in the vicinity of large towns or thickly populated districts.*

* Since M. Thaër wrote, another animal fertilizer, the guano, has been added to the list; of this, large quantities are now importing into England. Guano is, it seems, the European mode of pronouncing the Peruvian word "huano," or, manure. This substance exists in large quantities in some of the rocky islands off the coast of Peru, where, in the course of ages, it has been formed by the deposit of the excrements of innumerable multitudes of sea-fowl, who haunt these localities, especially during the breeding season.

"It forms irregular and limited deposits, which at times attain a depth of fifty or sixty feet, and are excavated like mines of red ochre. Its real origin was well known to the Government of the Incas, and its national importance fully understood. It was made a capital offence to kill the young birds on the guano islands."—*Professor Johnston, Jour. Roy. Ag. Soc.* vol. ii. p. 103.

It exists, according to M. Humboldt (*Davy's Elem. Ag. Chem.* 296), in the greatest abundance in some of the small rocky islands of the Pacific Ocean, as at Chinche, Ilo, Iza, and Arica. Even when Humboldt wrote, some twenty years since, fifty vessels were annually loaded with the guano at Chinche alone, each trader carrying from one thousand five hundred to two thousand cubic feet. The guano is found, according to Liebig (*Organic Chem.* 81), on the surface of these lands in strata of several feet in thickness, and is, in fact, the slowly putrefying excrements of innumerable sea-fowl that remain on them during the breeding season. It is used by the farmers of Peru chiefly as a manure for the maize or Indian corn, and, it is said, sometimes in the small proportion of about 1 cwt. per acre. "The date of the discovery of the guano, and of its introduction as a manure," says Mr. Winderfelt (*Brit. Farm. Mag.* vol. vi, p. 411), "is unknown, although no doubt exists of its great antiquity. In many parts of America, where the soil is volcanic or sandy, no produce would be obtained without the guano. It has been calculated that from 12,000 to 14,000 cwt. are annually sold in the port of Mollendo for the use of the country round the city of Arequipa. In the provinces of Taracapa, and in the valleys of Tambo and Victor, the consumption should be something more, as wheat, all kinds of fruit, trees, and plants, with the single exception of the sugar-cane, are manured with the guano; which is not the case with the district of Arequipa, where maize and the potato alone require it. In the district of Arequipa 3 cwt. of guano are spread over an extent of five thousand square yards (about an English acre); but in Taracapa and the valleys of Tambo and Victor, 5 cwt. are required. The land thus manured in Arequipa produces 45 for 1 of potatoes, and 35 for 1 of maize; where wheat manured with horse-dung produces only 18."

There are, it appears, three varieties of guano, which bear on the coast of Peru different prices. "The white guano is considered the most valuable, as being fresher and purer. It is found on nearly all the islands along the coast. The red and dark grey are worth 2s. 3d. the cwt.; a higher price is given for the white on account of its greater scarcity. It is sold at the port of Mollendo at 3s. 6d. per cwt., and at times, as during the war, it has obtained as high a price as 12s."

In a recent obliging communication (Dec. 29, 1842) from a gentleman who has resided many years on the coast of Peru (Henry Bland, Esq., of Liverpool), he observes, in answer to some questions which I had addressed to him with regard to the uses of guano, the soils, and the climate of Peru—

"The valleys on the coast of Peru consist chiefly of a light and sandy soil. *No rain* falls upon that part of the coast where I have seen guano used. Neither are the dews so copious as to be considered by the Peruvian farmer to be of any importance in promoting vegetation in the valleys.

"On the tops of the coast hills a slight verdure is produced by the dews in the winter season, but it does not remain for more than one or two months. The land of the valleys is irrigated; but without the limits of irrigation all is a desert, with the exception of the slight vegetation I have alluded to. This is the state of the coast from about 5 degrees to 22 degrees south latitude.

"I do not believe that so small a quantity as 1 cwt. of guano per acre is found sufficient for the soil upon any part of the coast of Peru. In the neighborhood of Arequipa the first crop is maize (Indian corn). The seed is sown in drills or trenches, and the bunches (three or four plants I call a bunch) come up about two feet apart. When the plants are six or eight inches above ground, a pinch of guano (as much as can be easily be held between the thumb and two fingers) is placed around each bunch, and the whole is usually irrigated immediately afterwards. Guano is again applied when the plant is about throwing out is fruits, a *handful* is then applied to each bunch, and irrigation immediately follows. The next succeeding crops, potatoes and wheat, are produced without any further application of manure.

"In the valley of Chaucay, distant from Lima about forty miles, a soil which without guano is capable of producing only 15 for 1 of Indian corn, with guano is made to produce 300 for 1. In speaking of guano, the Peruvians say, "Aunque no sea santo hace milagros."—Guano, though no saint, works miracles.

"Guano to be *good*, being in some measure soluble in water, can never be found in its most powerful state in any climate where rain falls; and, consequently, any that may be brought from the coast of Peru, taken from without the *limits of dryness*, must be of inferior value compared with that which comes from the Chinche Islands; situated in about 10½ degrees south latitude, and about ten miles distant from the main; and from Paquica, on the coast of Bolivia, in latitude 21° south. Upon these islands, and at Paquica, is the principal deposit of guano. Two or three cargoes of guano from the coast of Chili (where rain is frequent)

Vegetable Manures.

Purely vegetable manures are not nearly so active and energetic as those of animal origin; but, on the other hand, their effects are more durable. They appear to produce a more durable humus; but which is not so easily or so promptly absorbed by the suckers of plants. An addition of animal matter, of lime, or of alkalies, tends materially to accelerate their decomposition. A soil that is

have found their way into this country, and have, I believe, been sold for Chinche guano, thus injuring both the character of the best guano as a manure, and the importer of the genuine article.

"I may mention a circumstance to show the little estimation in which nitrate of soda, compared with guano, is held by the Peruvian farmer. On the coast of Peru nitrate of soda is produced at a distance of about forty-five miles from Iquique, the port at which the principal part of the nitrate is shipped. For mules, to transport the nitrate from the place where it is made to the port of shipment, the nitrate merchant, who sells for export, depends chiefly upon the farmers who reside in the immediate neighborhood where the nitrate is produced, and he can only secure their services by having always ready for them, in the port of Iquique, a return load of guano, which they carry back to manure their farms, after having carried a load of nitrate almost from their own doors to the port of Iquique."

Guano appears, in the state in which it has been lately introduced into this country, to be a fine brown or fawn-colored powder, emitting a strong marine smell; it blackens when heated, and gives off strong ammoniacal fumes. When nitric acid is mixed with it, uric or lithic acid is produced. It has been analyzed by various chemists. In 1806 an analysis of a very elaborate description was published by MM. Fourcroy and Vanquelin; they found in it a fourth of its weight of uric acid, partly saturated with ammonia and partly with potash; some phosphate of lime and ammonia, and small quantities of sulphate and muriate of potash; a little fatty matter; and a portion of sand. It has been more recently analyzod by Mr. Hennell, of Apothecaries' Hall, who found in guano:

	Parts.
Bone earth	30·5
Sulphates and muriates	3
Uric or lithic acid	15
Carbonate of ammonia	3
Matters volatile at 212°, consisting chiefly of water and carbonate of ammonia	12
Other organic matters	36·5
	100

The composition of guano varies, however, considerably. According to the analysis of MM. Voelckel and Klaproth, the varieties which they examined contained:

	VOELCKEL. Parts.	KLAPROTH. Parts.
Urate of ammonia	9	16
Oxalate of ammonia	10·6	0·0
Ditto lime	7	12·75
Phosphate of ammonia	6	0·0
Ditto ammonia and magnesia	2·6	0·0
Sulphate of potass	5·5	0·0
Ditto soda	3·3	0·0
Chloride of sodium (common salt)	0·0	0·5
Ditto ammonia	4·2	0·0
Phosphate of lime	14·3	10
Clay and sand	4.7	32
Undetermined organic substances, of which about twelve per cent. is soluble in water, a small quantity of soluble salt of iron, water	32·53	28·75

In a few words, it may be regarded as an impure compound of phosphate of lime, of urate of ammonia, and other salts. There is no doubt but that it is a very powerful manure; the very composition of its salts would indicate this fact.

According to the analysis of Professor Johnston the quantity of sand always present in the imported guano varies from two to eleven per cent; the sand consisting chiefly of mica, quartz, and felspar, the debris of the rocks of the coast of Peru. A specimen, which Professor Johnston examined, he describes as being "of a brownish-red color; it is evidently a very ancient deposit, and has undergone much decomposition. It consists of a powdery portion mixed with lumps of various sizes. The latter, when broken, exhibit an aggregation of minute crystalline plates, are much richer in ammonia than that which is in powder, and are free from sand and stones. When broken up, however, the lumps speedily lose their crystalline appearance, give off ammonia, even at the ordinary temperature of the atmosphere, and assume the condition of the powdery portion with which they are mixed."

It would appear, from the results of the various trials which have been recently carried on in this country upon the guano, that it is certainly a fertilizer possessing powerful effects; but it is pretty clear that it must be used in larger proportions than was formerly suggested—from 3 to 4 cwt. per acre appear to be the proper proportion. It is also evident, from the trials which I have witnessed, as well as from many whose results have been published, that it should not be applied in immediate contact with the seed. If, therefore, it is applied by the drill, which I believe to be the best mode, it should be applied by a separate coulter, and by the mode adopted in the improved Suffolk drills, by which the manure is deposited in the soil so much deeper and so much in advance of the seed as to allow a portion of the soil to be interposed between the seed and the manure beneath it. Like all other concentrated fertilizers, it is pretty certain that for the most successful development of its powers it requires a considerable supply of moisture, and will, therefore, produce the best results during wet seasons. It is used, it seems, in many situations in Peru, which are immediately afterwards irrigated.

From these facts, and from the general good effects which it has been noticed to produce on grass-lands in St. Helena, and in Lancashire, and other of the most rainy English counties, it is evidently well adapted for a top-dressing for meadows, and low situated lands in general. This, too, seems to accord with the opinion of Mr. J. Beadel, a very excellent cultivator and land agent, of Witham, who remarks, in a communication with which he recently favored me—"I think there can be no doubt as to genuine guano being a most powerful fertilizer; and were I about to use it, I should prefer applying it as a *liquid manure*.

"I am rather inclined to think that most of the top-dressings which we use will succeed better as a stimulant for green crops, and probably on grass-land, than for cereal crops; with me, I have found *wheat* more subject to mildew when so dressed. The straw then is dark and very vigorous, but the kernel does not plump up. It may be that I used too much, and so failed; the appearance was very like corn grown on a dung-hill, rank but not *corny*."

I think also, from my observations, that if the guano is well-mixed with three or four times its weight of finely sifted earth, and suffered to remain for some weeks in this state before it is used by the drill or applied broadcast, that its effects would be more considerable, and the sometimes too powerful effects of guano upon the growing crop avoided. [*Johnston on Guano.*

from time to time ameliorated with purely vegetable manures, preserves its fertility better; it retrieves that richness and succulency which it had lost, in a much more durable manner than it would if ameliorated with animal manures only; this is the reason that land which has become very much impoverished or exhausted recovers itself so much more effectually when suffered to repose, than it does when manured.

We have already enumerated the vegetable substances which may be used as litter with the greatest advantage; these substances when mixed with the excrements of the animals easily become decomposed, and serve to moderate the rapidity with which the animal manure putrefies.

But there are also other vegetable substances which in their separate states may be applied to the manuring of that soil whence they have sprung. They may be restored to the land in one of two ways, viz., either accidentally or intentionally.

There cannot be a doubt that all those weeds which are allowed to produce their flowers and then buried by the action of the plow, tend to augment the fertility of the soil. For, although the development of almost every plant is in some measure dependent on the mould or humus contained in the soil, yet numerous experiments serve to prove that plants likewise absorb aeriform substances, and in all probability the constituent parts of decomposed water as well, which they transform into organic matters by means of their own internal mechanism. It may, therefore, be admitted as a fact, that every vegetating plant increases the organic matter and humus of the soil, if it perishes in the same spot in which it originally sprang up. This is one reason that a complete fallow in which a great quantity of grass and weeds spring up after each plowing, may be regarded as equal to a slight manuring, and that independently of all the other advantages which it produces. The more abundantly and vigorously weeds spring up, and the greener the soil becomes between each plowing, the more is it benefited. Those fields which produce the greatest quantity of hedge-mustard (*erysimum*) derive most benefit from fallowing, independently of the advantage resulting from the destruction of this weed.

There is not a single vegetable substance, even down to the stubble which most crops leave behind them, which does not restore some portion of mould to the soil. The longer this stubble is, the greater effect does it produce; therefore, where a similar quantity of manure is bestowed on the land, the soil becomes less exhausted in those districts where it is customary to leave the stubble long when the corn is reaped. But it is highly necessary that this stubble should be buried without loss of time, as it appears that it only becomes decomposed when buried in the soil, but that when exposed to the air it dries up and turns to powder. In general the stubble of plants which possess long thick roots and stems deposits a larger portion of vegetable matter in the soil than the stubble of corn-fields; but that which is productive of the most beneficial effects when buried with roots and stems is the stubble of vegetables which have not borne their seed, or become dry and strawy, and which contain a considerable quantity of mucilaginous particles. Hence arise those ameliorating effects attributed to vetches and clover grown while green: these plants shed a portion of their leaves and stems on the soil, and thus enrich it before they are gathered, and generally put forth fresh leaves and shoots previously to being plowed into the soil.

Nothing tends to improve land more than the turf or accumulation of herbage which is successively formed during a number of years. The thick tissue of the plants and their clusters of roots, the animal matter of the dead worms and insects, the excrements of the cattle which have been pastured—these all combine to render the soil peculiarly fertile and capable of yielding several successive crops without the addition of fresh manure. It is quite an erroneous supposition to attribute this amendment solely to rest, since rest alone could only have been productive of a negative good. The better the condition of a soil when laid down to grass, the more herbage will it be able to produce, and the more will it profit by the term of repose allowed to it; not only on account of its inactivity, but because its productive powers are much greater.

The erroneous opinions which are in general entertained with regard to the effect produced on land by repose, have perhaps given rise to the prejudice in favor of, and in some degree contributed to the maintenance of the custom of only

laying down those portions of land to grass which are completely exhausted, in the hope that by so doing they might be restored to their pristine fertility and activity. And it cannot be denied that repose does produce this effect, because no soil is ever so thoroughly impoverished as to be incapable of putting forth some few shoots and sprouts of herbage: but the improvement which results is much more backward, and its effects much weaker than if the land had been in a better condition when abandoned to Nature. The more fertile a soil is when laid down to grass, the more leaves and roots and patches of herbage does it put forth, the more worms and insects are engendered, the greater number of cattle are pastured on it, and, consequently, the greater quantity of excrements are voided over it: thus, therefore, the more it abounds in nutritive juices when first laid to grass, in the greater degree will it be benefited by the period of repose.

We bestow a most active and abundant vegetable amendment on a soil when we sow it with plants adapted to its nature, which will flourish and attain the highest state of development; and then when they have begun to flower, either bury them by the action of the plow, or have them eaten off the ground, or trodden in by cattle. This practice is of great antiquity: it was held in high estimation among the Romans, and exists at the present day in Italy. There it is that the amelioration produced by a crop which has been buried while green is the very best that can be bestowed on a soil, and is capable of bestowing on it the utmost degree of fertility of which it is susceptible: indeed, they even prefer it when there is a sufficiency of animal manure. The climate of Italy certainly is more favorable to the success of this practice than ours, because those crops which are intended to ameliorate the soil are not sown until after the harvest, which is more forward there, and because those crops have then more time than they absolutely require to enable them to attain their highest degree of vegetation. Of all the plants used for this purpose, none were so much prized as the *lupinus albus* (white lupine.) This plant has from time immemorial been cultivated solely for this purpose, and still continues to be so in the present day; the extreme bitterness both of its seed and stem precludes all possibility of using it as food, either for men or animals.* We have analyzed the white lupine superficially, and mean to institute a more minute examination of it, and we found that it contained a considerable portion of mucilage, which may perhaps explain its peculiar adaptation for the improvement of land. Sismondi, in his "Agriculture of Tuscany," tells us, "that the seed of the lupine, after having been deprived of its vitality, is buried at the root of olive trees in order to manure them." We have only to institute a few experiments, and we shall soon discover whether or not this plant is sufficiently distinguished by its fertilizing and ameliorating properties to make it worth our pains to cultivate it. It is well known to all florists and gardeners that it thrives exceedingly well in this climate. I cannot, however, at present determine whether, if sown after a crop of rye, it would become sufficiently developed to be buried with advantage; but we have several other plants which are equally proper for the purpose, if not more so.

The following are the properties which ought to be united by those plants which are cultivated for the purpose of being buried as vegetable manure.

(*a*). The plant chosen ought to be one adapted to the texture, qualities, humidity, and situation of the land on which it is to be sown, in order that, so far from vegetating slowly, it may shoot up and flourish with all possible rapidity.

(*b*). The seed must neither be expensive nor scarce, or it must be of such a nature that a small quantity of seed will sow a considerable extent of land.

(*c*). This plant must attain its full vigor and development in the shortest possible space of time, in order that the requisite number of plowings may be bestowed on the fallow, if the crop be sown on fallow land, or that it may succeed the harvest of some other crop, and attain its development that same year.

(*d*). It must be well adapted for the purpose of keeping the soil loose—must penetrate deeply into it by means of its roots, and cover it with its leaves.

(*e*). It must contain a considerable portion of mucilage, or of some other vegeto-animal substance, which is analogous to animal matter.

(*f*). It must be disposed to putrescence.

There is no plant that unites all these qualities in so eminent a degree as the

* The Italians have a method of preparing the lupine which deprives it of its bitterness; I have frequently seen it bought and eaten by the peasantry, who appear to like it very well. [*French Trans.*

spergula arvensis (corn spurry); various trials with regard to its fitness for this purpose have been made, almost all of which have turned out well. (*Annals of Agriculture of Lower Saxony, fourth year*, section 1st, A.) Previously to plowing this plant into the soil, cattle may be allowed to pasture slightly upon it; but then they must be suffered to remain there during the night, if we would not take away a considerable portion of the advantages which might otherwise be derived from this practice.

Various other plants are used for this purpose; *those which bear oleaginous seeds*—as *rape*, &c.—are peculiarly well adapted for it; several vegetables appertaining to the class diadelphia—as *peas*, *vetches*, and *beans*. It is chiefly in England that vegetables are used for this purpose; even there, these crops are often on the ground previously to being covered by the plow; and in order to effect this object, all kinds of cattle, and especially pigs, are suffered to feed on them. These last-named animals fatten rapidly there, and thus contribute towards paying for the seed, which would otherwise become too expensive.

The same use is occasionally made of buckwheat; when this plant is green it furnishes a very nutritive fodder.

Frederick the Great, himself, relates that radishes have been sown chiefly with a view to this purpose; and my estimable friend, Harmstadt, who relates various experiments on this subject, assures us that *beet*-root, mixed with different substances, produces a very active species of manure. (*Annals of Agricultural Chemistry, by Hermbstadt*, vol. i. A.)

We must not overlook a practice which has been preserved in a manner so marked and consistent in all those places where it is known; on the contrary, I think that it deserves to be analyzed with all possible attention, and to be inquired into in all its bearings. At first sight, we cannot help fancying that there is a degree of extravagance in causing a crop which might be mown, and consumed in the stable by animals, to be crushed by the roll, or trodden down by cattle. Many persons are of opinion that this kind of manure will be equally as beneficial to the land if the crop is made to pass through the bodies of the animals, as it would be if the plants were buried at once; and they are quite right. But the extent of land which can be sown with crops of this nature will always be so great as to produce far more fodder than is necessary to supply the wants of the cattle, of which a certain limited number is usually kept; and it frequently happens that it is not possible to procure a sufficient number of laborers to gather the whole of these crops. Nor is this all: the Italians have observed that some kinds of lands are materially benefited by occasionally receiving an amendment composed solely of vegetable matters; or, as they term it, a *refreshing amelioration.*

Many authors have recommended this practice for the amelioration of distant or detached portions of land only, or of such as have been exhausted, or are newly brought into cultivation; but it would not benefit impoverished soils much, because the plants sown on them for the purpose of being turned into the ground as manure, would vegetate too feebly. Land must contain succulent matter in order to be able to produce them with any degree of success; therefore, this species of manure is better calculated to preserve the fertility of a soil than to lay the foundation of it; and, in all probability, it is on that account that it has hitherto been so little used among us. If we come to regard a field well covered with a thick crop of vegetables, we may easily conceive what may be expected from such a quantity of stems and leaves when buried in the soil for the purpose of manuring it.

All kinds of vegetable refuse may be used as manure, if collected together and decomposed by the admixture of a small quantity of animal substances or lime.

The sweepings of the kitchen, weeds, wood, rotten saw-dust, soot, tanner's spent bark, or oak bark, from which the greater part of the astringent principle has been extracted, may all be converted into manure. Those vegetable substances which yield a considerable portion of potassa, on being burned, are eminently adapted for the amendment of land; of this number are the stems of tobacco plants, maize, straw, &c.; but these should only be thus employed when no other use can be made of them.

The haulm of potatoes also possesses the means of ameliorating land in a particularly high degree; but, in order that it may putrefy rapidly, it must be gath-

ered together or mixed with dung while in a green state. An attempt has been made to form a kind of compost with potato haulm, turf, and a little lime, which is said to have produced excellent effects. No insignificant quantity of this substance will be yielded by an acre of potatoes. If the haulm is left on the ground and subsequently plowed in, it becomes gradually decomposed; this circumstance may serve to explain the reason of some persons having believed that potatoes are not a very exhausting crop. The process of decomposition, however, progresses very slowly, and retards the sowings a little.

There are also several other very useful plants, the stems and stalks of which shoot up to a considerable hight, and which, independent of their actual produce, are capable of yielding a large quantity of mould—a circumstance which, doubtless, ought to be taken into consideration in making choice of one kind of product rather than another; of this number is the *helianthus annuus* (annual sunflower), and the *helianthus tuberosus* (Jerusalem artichoke).

Sea-weeds and pond-weeds may likewise be entered in the class of vegetable substances which yield an active and energetic manure; among the former we may particularly notice the variety of the *fuci*, and among the latter the *chàra vulgaris* (common chara), which is always covered with a calcareous mucilage; but if we would derive all the advantages from these plants which they are capable of yielding, we must, in the first place, cause them to undergo decomposition, either by themselves or mixed with a little animal dung.

The mud which is found at the bottom of rivers, ponds, and other places in which stagnant water has remained for any length of time, and the scourings of old ditches, are matters which ought to be included in the class of vegetable manures; for although this mud is sometimes mixed with animal matter, and likewise contains a great proportion of those earths of which the neighboring soils are composed, still the vegetable substances predominate in quality if not in quantity. This substance may in general be assimilated to vegetable manure; that is to say, it is less energetic and stimulating than animal manure, but more durable in its effects, and richer in saccharine and extractive matter. It is, therefore, termed "refreshing manure," and the most durable effects are attributed to it.

In the section on Agronomy, we have already spoken of the different kinds of earth, and of their nature; and have carefully distinguished those which are sour or acid from those which are devoid of acidity.

It is very advantageous to an agriculturist to discover such a store of fertilizing substances in his own estate. However great may be the difficulties and expenses attendant on the extraction and transport of such a treasure to the fields, they will always be fully remunerated, and those who have it in their power to advance the requisite outlay will find themselves amply repaid. I must confess, however, that these expenses are always very great, and that they seldom yield much profit during the first years of application.

The principal inconvenience attendant on the extraction of mud or mould arises from the difficulty in clearing it from water, for it is seldom sufficiently dry when first extracted. This may occasionally be obviated by digging furrows for the purpose of carrying off the moisture; but, in general, the ditches or excavations in which the mould is found are surrounded by elevations, so that it is impossible to find any outlet through which it may escape. In this case, recourse must be had to machines for the purpose of drawing up the water by pumps, or to some other hydraulic engines. This operation must either be performed in the summer, or during the hard frosts of winter; it is scarcely possible to effect it in the spring and autumn, because the laborers, having to stand in so much wet, would be unable to bear the cold. In the midst of summer this mud is apt to exhale pestilential vapors, which are calculated to engender fever and various other diseases, not only in the laborers employed in the operation, but also in the inhabitants of the vicinity. This is especially the case when the mud has lain under water for a considerable period. It is, therefore, generally preferable to execute this operation in the winter season, provided that care has been taken during the autumn to divest the water which might otherwise prove an obstacle. This operation may be rendered very expensive, by the difficulty which will be experienced in cleaving and detaching the mud when it is frozen hard, as well as by the necessity of carting and transporting the ice with which the mud is firmly united.

This kind of manure should never be conveyed to the soil for which it is inteuded until it is perfectly dry. When in a moist state, it must first be laid in some place where it may be deprived of the moisture, and left there until every particle of water is evaporated; because its weight and volume is thus considerably diminished, and the carriage of it rendered less difficult. This kind of manure is usually conveyed from place to place by means of tumbrels or dung-carts, or in large wheel-barrows, the former being drawn by one horse. Local circumstances alone can enable us to decide which of these two vehicles are most expedient to be used. If the mud has only to be carried a little way, wheel-barrows will certainly be most proper; but where it has to be conveyed a considerable distance, tumbrels will be least expensive. These latter cannot, however, be used when the ground over which the mud has to be conveyed is of a marshy nature; in that case a pathway, composed of boards, must be made.

This operation is generally executed by the task or job. Where this is the case, those who undertake it reckon their work by cubic measure or by the cart-load. Nothing definite can be said with respect to the usual price of such labor, excepting that it ought to be better paid than almost any other, because it is the most unhealthy and laborious of all agricultural operations. Besides, it is absolutely necessary that the laborers employed should have some little brandy to drink.

If the mud is completely putrefied, it should be put in little heaps, in order that it may dry more quickly, and thot a greater extent of surface may be exposed to the influence of the atmosphere. But if it still contains a considerable quantity of undecomposed vegetable matter, of moss, or aquatic plants, it should be formed into large heaps when dry, in order that it may thus become heated, enter into fermentation, and the vegetable matter be thoroughly putrefied. This putrefaction, or decomposition, will be greatly accelerated if a little calcined lime or fresh horse-dung be mixed with the mud.

These additions are particularly necessary to mud which contains an acid quality, even should it be completely decomposed. It is often advisable to postpone the addition of these substances until the matter in question shall have been carried to the land on which it is to be used; and this is especially the case when, instead of being spread over it at once, it is left there in heaps, as the double carriage of the lime, ashes, &c., is thus saved. This remark is not, however, applicable to mud which dries quickly; for then, instead of making it into heaps, it is carried at once from the place whence it is extracted, to the land over which it is to be spread.

If we would have this mud produce prompt and immediate effects, we must add to it either animal manure, alkalies, or alkaline substances, which will increase its solubility; but it is only necessary to effect this mixture in the heap, when the humus which it contains is of an acid nature. After the mud has been spread over the soil, and these substances have also been added, the mixture may be effected by means of shallow plowings, and repeated and careful harrowings. An admixture of marl, especially if it contains a considerable portion of lime, that of calcined lime, or animal dung, with the mud used for the amelioration of land, has always appeared to be productive of very beneficial effects. It is not necessary that any very considerable quantity of manure should be applied to land ameliorated with this substance; one half of the usual proportion will be quite sufficient: if more is added, the corn crops which succeed to an amelioration of this nature will inevitably be laid. But if the mud is turned in by a plowing, and no portion of manure is added, its effects will not then be perceptible during the first crop, whatever they may be in the second; and should this substance be at all of an acid nature, it will even prove injurious. Nevertheless, sooner or later the advantages resulting from it will become evident. They generally begin to appear about the third year, and then the effects produced are much more durable.

The quantity of this substance which is said to have been, or which ought to be, applied to the amelioration of a field varies very much: in some places a load of sixteen cubic feet is allowed for a square perch of land, and, consequently, one hundred and eighty loads per acre; while, in other places, only twenty such loads are allowed for an acre of land. Some persons affirm that it ought never to be spread over the ground in less than one inch in thickness, while others maintain that the thickness on the land ought never to exceed a quarter of an inch. But

this depends in a great measure upon the composition and nature of this manure, since it will cause a considerable difference in the effects produced by it, whether this substance contains a great proportion of those earths of which the soil to which it is applied is composed, or whether it contains those of an opposite nature, or consists chiefly of vegetable mould, properly so called. It not unfrequently happens that a perfectly black mud will only contain eight or ten parts in a hundred of humus, and all the rest earth; and, nevertheless, its addition to the land will be productive of beneficial effects, especially when the kind of earth which it contains is of a totally opposite nature to that of which the soil to which it is applied is composed. Thus, for example, pure clay, refined by water, is beneficial and efficacious when applied to a sandy soil; but if the mud were chiefly composed of silicious earth, it would not be productive of any more effect than that resulting from the humus contained in it. In the latter case, therefore, a large quantity must be applied, if we would effect any sensible amelioration in the soil. After having chemically analyzed the mud, the quantity of it must be calculated which it will be necessary to apply to a certain portion of land in order that each square foot, which being six inches deep, is equal to half a cubic foot and weighs about fifty pounds, shall receive at least a pound of pure humus; consequently, should this substance not contain more than ten parts in a hundred of humus, ten pounds of it must be applied to every square foot. This proportion will raise the quantity to be applied to two hundred and fifty-nine thousand pounds per acre; which, supposing each load to contain sixteen quintals, will make one hundred and sixty-two loads per acre. The more humus this substance contains, the smaller proportion of it will be requisite to ameliorate a piece of land. I do not mean to assert that a small quantity of this mud will not be productive of any effect, but merely that a sensible or durable effect must not be expected from any amelioration of this nature in which less than two parts in a hundred are added to the soil.

The weight of this mud is also susceptible of great variation; it is lighter in proportion as it contains a greater quantity of humus, and especially when it comprises substances which have not become thoroughly decomposed; the strength of a load must not, therefore, be estimated by measure, but rather by weight.

It is of very great moment that this substance should be carefully mixed with the soil, and that this mixture should be effected at once, or, at any rate, before the termination of the year in which the manure is transported to the land. If it is suffered to lie there long without being incorporated in the soil, it agglomerates, and forms itself into clods, which are a considerable time before they fall to powder and become equally divided, especially in coherent and tenacious soils; and, until it is thoroughly divided and incorporated, it produces little or no effect. It will, therefore, be better never to attempt to sow any crop after the first or even the second plowing which succeeds to the application of an amelioration of this nature, but to suffer the land to lie fallow, during which time a perfect incorporation of the mud with every portion of the soil may be effected, by means of shallow and repeated plowings, and careful harrowings. This is particularly necessary where the mud contains a considerable portion of earth, properly so called. The mud which is obtained from marshes or bogs, and which is not entirely decomposed, may be suffered to remain on the soil without producing any inconvenience, because, during its decomposition, it divides and pulverizes without difficulty. One of my correspondents informs me that he has found it peculiarly advantageous to sow, on land thus amelioroted, some vegetable, the growth of which is very rapid, and which is intended to be plowed in as manure: common spurry has appeared to him to be peculiarly adapted for this purpose.

Peat is a substance which may also be employed for the amelioration of land, and especially of light friable soils; but when this substance contains acid, or, what is still worse, bitumen, it must be made into heaps, and suffered to remain there for a considerable period, mixed either with calcined lime, or strawy stable dung, or, lastly, with very fine sand, which many persons assert is capable of destroying all baneful properties. These peat heaps must be kept moderately moist; and the best and most advantageous way of keeping up the requisite degree of humidity is to water them with urine or dung-water. Great advantages have

frequently been derived from forming heaps of alternate layers of peat and calcareous marl; they must be very frequently stirred, and turned over.*

If peat-dust has remained in heaps for a long time, it may be used as manure without the addition of any mixture, and is peculiarly adapted for the amelioration of argillaceous and tenacious soils.

In the neighborhood of turf pits this proceeding will be most profitable, on account of the trifling expense which it will cost.

Lastly, coal and bituminous earth, impregnated with sulphate of iron, must not be omitted in the enumeration of that class of manures which are of a vegetable origin; this substance has been employed with great success, and for the first time on a large scale, in the amendment of land at Oppelsdorf, in the neighborhood of Zittau. But, as the principal part of the success attendant on it is mainly attributable to the sulphate of iron, we shall recur to this subject when speaking of those manures which are derived from saline substances.

We shall reserve our remarks on ashes as a manure to the same place, although this substance owes its existence to vegetable matters.

Mineral Manures.

As an excessive proportion of some one of the elementary earths, and even of humus, is liable to prove injurious to the soil, by deranging the equilibrium of its physical properties, destroying its consistence, or its disposition to retain moisture, &c. attempts have been made to remedy this evil by the application of another earth of diametrically opposite properties. This practice may be termed the *physical amelioration* of the soil, in order to distinguish it from the *chemical amelioration*, which comprises not only the use of manures, properly so called—that is to say, of the aliments destined for the nutrition of vegetables—but also of the substances which develop those aliments, and prepare them for being taken up by the roots of plants.

This amelioration of the physical qualities of the soil, by the addition of an earth which is opposite in its nature to those composing the land which it is intended to ameliorate, is undoubtedly within the list of practicable undertakings, but there are very few cases in which it can be effected with any degree of advantage. It is hardly possible to correct the defects of an argillaceous and tenacious soil with sand, or those of a sandy soil with clay, excepting in those cases in which the kind of earth necessary to effect the required amelioration is found in the inferior stratum of the soil to which it is to be applied. There is no doubt that, in such cases, the necessary amelioration may be effected by means of deep plowings—so directed, however, as not to bring too thick a layer of the virgin earth to the surface. In general, the new earth can only be raised from the bed on which it rests by means of deep trenches or excavations, from which it is dug and thrown up by the shovel, and then spread over the surface; while that earth which was formerly on the top is cast into these excavations to fill them up.

* Mr. Dixon, of Hathershaw, in Lancashire, in his Prize Essay, thus describes the result of his long experience:—"My farm is a strong, retentive soil, on a substratum of ferruginous clay. My object was to improve its texture at the least cost. For this purpose we carted great quantities of fine saw-dust and peat earth, or bog; we had so far to go for the latter, that two horses would fetch little more than three tons in one day; one horse would fetch three cart-loads of saw-dust in the same time. Having brought great quantities of both peat and saw-dust into my farm-yard, I laid out, for the bottom of a compost heap, a space of considerable dimensions, and about three feet in depth; three-fourths of this bottom was peat, the rest saw-dust; on this we conveyed, *daily*, the dung from the cattle-sheds; the urine, also, is conducted through channels to wells for its reception (one on each side of the compost heap); common water is entirely prevented from mixing with it. Every second day the urine so collected is thrown over the whole mass with a scoop, and at the same time we regulate the accumulated dung. This being continued for a week, another layer, nine inches or a foot thick, of peat and saw-dust, (and frequently peat without saw-dust,) is wheeled on the accumulated heap. These matters are continuously added to each other during winter; and in addition, once in every week, never less than 25 cwt.—more frequently 50 cwt.—of night-soil and urine; the latter are always laid next above the peat or bog earth, as we think it accelerates their decomposition. It is, perhaps, proper here to state that the peat is dug and exposed to the alternations of the weather for several months before it is brought to the heap for admixture: by this it loses much of its moisture. Some years' experience has convinced me of the impropriety of using recently-dug peat: used in the manner I recommend, it is superior and more convenient on every account—very much lighter to cart to the farm-yard, or any other situation where it is wanted; and so convinced am I of its utility in composts for every description of soil, except that of its own character, that wherever it can be laid down on a farm at less than 4s. per ton, I should recommend every agriculturist and horticulturist that can command it, even at the cost here stated, to give it a fair trial. So attractive and retentive of moisture is peat, that, if liberally applied to an arid, sandy soil, that soil does not burn in a dry season; and it so much improves the texture and increases the produce of an obdurate clay soil, if in other respects rightly cultivated, that actual experience alone can fairly determine its value." [*Jour. Eng. Ag. Soc.*, vol. i. p. 136.

If the ameliorating earth has to be procured from any considerable distance, or to be raised from a great depth in the ground, these operations become so expensive as only to be practicable in some few localities and cases; for, in order to effect such an amelioration in the soil—or, in other words, to alter the nature of the layer of vegetable mould—a very large quantity of earth will generally be requisite; so great, indeed, that the soil will often be bought too dearly. It is, therefore, necessary to calculate what is the relation which exists between the constituent parts of the earth which is to be procured, and those of the land which we wish to ameliorate; and, consequently, how much of the former will be requisite to effect a proper and advantageous mixture throughout, at least, a depth of eight inches of the vegetable mould of the latter. We shall thus be enabled to ascertain what will be the cubic measure requisite for a certain given extent of space; and to calculate, with reference to all the local circumstances of the case, what will be the expenses of raising, loading, carrying, spreading, &c. A rough estimate of these things may be made at first, which we can subsequently reduce, at our leisure, to a more definite calculation. To this must be added the consideration, that it is exceedingly difficult to effect a thorough combination of sand and clay, unless these substances are of a marly nature, or contain calcareous particles: where such is not the case, these earths cannot be sufficiently divided to incorporate completely with each other.

If we convey sand to an argillaceous soil, or clay to a silicious soil, the mixture cannot be effected without repeated plowings, the two or three first of which must be as superficial as possible, and the others gradually deeper; to these must succeed harrowings, and the clods must be broken by the action of the roller, or by mallets. The period selected for the performance of all these operations must be when the clods have attained the degree of dryness in which they can be most easily divided and broken by these proceedings: this generally occurs about the middle of summer; but it is rarely possible to complete the operation in the course of one summer. The division of the earth may be accelerated by mixing dung or calcined lime with it, or by sowing it with such plants as have roots sufficiently strong to penetrate the clods, and which may subsequently be plowed into the soil as manure. When the ameliorating earth has not been thoroughly blended and incorporated with the soil, so far from improving, it rather tends to deteriorate the land for a very considerable period, for there are very few plants that will not be injured by their roots coming in contact with a soil of so heterogeneous a nature. When we read in the works of ancient authors, or hear accounts of the success with which ameliorations of this nature have been attended, we may generally feel convinced that the earth which was applied was a marl of a more or less calcareous nature. It was not long ago that the operation of marling land was designated in Holstein, ameliorating it with earth; and the persons who performed it, persisted in asserting that it was clay they applied, because at that time marl was scarcely known or recognized there. No really ameliorating effect can be expected from clay until it has been exposed for several years to the influences of the atmosphere, as is the case with that which has formed the sides of ditches, dykes, &c., or of which walls have been constructed. Clay which has been thus exposed to the air is more easily divided, and blends with the soil more intimately.

The physical condition of clayey or argillaceous soils is ameliorated in a very durable manner by paring and burning them, because this operation renders their texture more open and porous, and deprives them of their too great adherence for water; their fragments are thus rendered less coherent, and, in point of physical properties, somewhat similar to sand. Besides, in all probability, this operation likewise produces a chemical effect which has not as yet been sufficiently explained.

Silicious earth is that which is most frequently and advantageously used in the amelioration of rich soils which are deficient in consistency, and disposed to retain moisture. The sand which is conveyed to soils of this texture, gradually penetrates into the mould and fills up its spongy texture; it must, therefore, be spread over the surface and there left. It is never so efficacious as when it is spread over land which is covered with grass; it then renders the vegetation of plants growing there more vigorous, and produces effects equal to a very active manure. Experiments without number which have been made on lands of this

kind, prove beyond a shadow of doubt, that sand produces a more beneficial effect than even the most energetic manure: in fact, manure would be rather injurious than otherwise to soils of the kind of which we are now speaking.

The lime which some soils naturally contain has also a considerable influence on their physical properties. Nevertheless, when we add this substance to a soil, we think only of the chemical effect, because lime can seldom if ever be employed in sufficiently large quantities to produce any sensible alteration in the consistency of the soil.

Both the chemical action of lime and the effect which it produces as a manure, appear to be of two kinds. On one hand, it acts on the humus by accelerating its decomposition, and rendering it soluble, and thus fit to enter the minute fibres of the roots of plants. This is the reason that an amelioration composed of lime is the more efficacious the richer the soil is in humus, and that its action is the more sensible in proportion as this humus is of an insoluble nature. Lime deprives sour humus of its acidity, and renders it fertilizing. But, on the other hand, there is every probability that by means of its carbonic acid, lime also produces some other effect, and furnishes the plants with some actual nutritive matter. The roots of certain vegetables in particular appear to have the faculty of depriving lime of its carbonic acid, which it immediately re-absorbs in equal proportion from the atmosphere with which it comes in contact. It cannot be denied that an amelioration of lime invariably produces some effect, even on land which contains a very small quantity of humus, and that a repetition of this amendment is never without its effects; although they are, of course, very far inferior to what they might have been if the soil had contained more humus, or had been manured with vegetable or animal matter capable of producing that substance. Besides, every one must be aware, that lime communicates a peculiar degree of vigor to some plants, and that the roots of these can even penetrate rough limestone, and in a manner decompose it. This remark is particularly applicable to sainfoin, the tap-root of which penetrates from ten to twenty feet deep into calcareous stones, and there puts forth clusters of lateral roots which render the stone loose and friable all around them. The deeper the roots of this plant penetrate, the more vigorously does it shoot, even on calcareous rocks or stony places which are only covered by a very thin layer of poor soil.

Lime which has been calcined and deprived of its carbonic acid is much better adapted for the amelioration of land, and far more efficacious than carbonate of lime. In its former state, it contributes infinitely more to the decomposition of decomposition of the substances with which it is united, and acts far more efficaciously on organic matter than it does in the latter. But we must admit that its increased efficacy arises from another cause. It very soon re-absorbs equally as much carbonic acid from the atmosphere as it lost during the process of calcination, especially when, after having been thus reduced to powder, it is mixed with the superior layer of the soil. But the carbonic acid which it has thus recently regained is not in general so intimately combined with the lime as not to be easily absorbed by any plant the roots of which come in contact with it. The lime continues to attract fresh portions of this substance, and thus a permanent communication of carbonic acid is established between the lime, the roots of the plants, and the atmosphere. This may serve to explain the reason that even calcareous soils may be remarkably fertilized by the addition of lime; and that a sensible effect is produced by an addition of this substance, even when the soil already evidently contains a greater quantity of it which has been accumulated there by former amendments.

On no soils are the effects of lime so beneficial as on those which contain a great quantity of sour humus prejudicial to vegetation, or on those which have been supplied more or less abundantly with animal manure for a considerable period without receiving an application of lime, or of some other substance of a similar nature. In the latter case, it is frequently much more efficacious than an amelioration of stable manure would be; but it soon impoverishes the soil so much that in a very few years it becomes indispensably necessary to manure it abundantly with rich animal or vegetable matters. As some portion of humus, although in all probability of an insoluble nature, always remains in arable land even when it appears to be most exhausted, it of course follows that an application of lime will always be productive of very marked effects, even on the poor-

est soils, because it will call into action all the nutritive particles which they contain. A second amendment of a similar nature bestowed shortly after the first will be productive of some, although in general of much less benefit; and the effect of each subsequent amelioration of this nature will be progressively diminished unless the soil receives an additional supply of humus. The effects of lime are far more marked on some crops than they are on others: various observations have given rise to the opinion that it is more efficacious when applied to spring corn than to autumnal crops; and that it is peculiarly favorable to vegetables, and also to clover and grasses.

Argillaceous soils are better able to bear repeated ameliorations of lime than those of a sandy nature; because in the first place, the physical action of this substance tends to loosen the texture of the land; and in the second place, its chemical action lessens the disposition which all clays have to retain humus. When marshes or bogs have been drained and are brought into cultivation, they are capable of bearing repeated and abundant ameliorations of lime, because they always contain a variety of substances susceptible of decomposition, and on which the lime can exercise its solvent influence. The effect produced by lime on land of this nature is much more beneficial and durable than that of any other manure.

On the other hand, repeated ameliorations of lime will soon totally exhaust and impoverish poor and sandy soils, and reduce them to absolute sterility, even though each separate application seems to be productive of some good effect. If the lime is unable to find any organic matter on which to act, or does not meet with clay—an earth with which it has in all probability a disposition to combine, and with which it forms marl—it then unites with the sand and hardens into a kind of mortar, which cannot be dissolved without difficulty. When such soils have been too frequently and abundantly manured with lime, the action of the plow brings an immense number of pieces of hard mortar to the surface, which are with difficulty divided. Wherever this is the case, the land must receive repeated manurings before it will again be capable of bearing good crops. The truth of this statement has lately been demonstrated on several estates in Silesia, and occurrences of a similar nature have been remarked in those countries of England in which the triennial rotation with a fallow is practiced, and where few cattle are kept, and which possess an abundance of lime.

In general, lime is not used until it has been calcined; that is to say, until all the carbonic acid is disengaged; either because it is then productive of the most sensible effects, or because it is only when in this state that it falls to powder and can be intimately combined with the layer of vegetable earth. On this account, the pulverization of calcined lime is expedited as much as possible, and they hasten to mix it with the soil or with those organic matters which are to be used as manure.

There are two ways of effecting the mixture of lime with the soil. The first consists in placing the unslacked lime in the vicinity of some spot well provided with water, and then throwing a sufficient quantity of that fluid on it to reduce it to powder, but not enough to form it into a paste. After the lime has been thus watered, it must be stirred up, and those lumps which still remain, taken out to be moistened again, and thus reduced to powder. During this operation the lime regains its water of crystalization which it had lost during the process of calcination; but it absorbs very little carbonic acid, and, consequently, preserves its causticity. In this state its acts most energetically, and is best adapted for the purpose of breaking down and destroying the texture and organization of all undecomposed vegetable and animal matter contained in the soil, as insects, the fibres of plants, and even the seeds of some weeds, all of which it dissolves and transforms into a very fertilizing mould. When lime is thus powdered, it must be conveyed to the fields without loss of time and spread over the soils with shovels. The land should have been previously plowed. As the dust of lime is both disagreeable and injurious, care must be taken that the laborers employed in spreading it, and the teams that have brought it to the fields, shall stand to the wind. In those places where lime is much used for the purpose of ameliorating land, cylinders turning on wheels, somewhat similar to those attached to drill plows, are adjusted to the carts used in this operation; and the pulverized lime is thus equally spread over the soil.

The second mode of proceeding, and that which is in most common use, consists in conveying the lime to the land to which it is to be applied, and there dividing it into little heaps, each containing about a bushel, and situated at suitable distances from one another. After these heaps are formed, they are covered with shovelfuls of earth taken from the ground around them, and little furrows or gutters are made down the surface to admit the water running off. When it is supposed that the lime is almost or quite divided, a shovel is introduced; if it meets with any lumps, the heap is made up afresh, and again covered with earth. There is no doubt that this practice of covering the lime originated in an erroneous idea that that substance lost some volatile portions by exposure to the atmosphere: but this layer of earth is really useful; for without such a protection in rainy weather, a crust would be formed over the heaps, which would not only prevent the water from penetrating into them, but would be with difficulty powdered, and almost always remain lumpy.

A third way of preparing lime for being spread over the ground, consists in forming it into large heaps with turf or peaty earth, when these substances can be procured in the immediate vicinity. These heaps should be made near ditches or trenches dug for the purpose of carrying off water, or of declivities or flat surfaces covered with reeds, and which are about to be brought into cultivation. The lime is suffered to remain there until it is quite pulverized, and has decomposed the turf with which it is united: the heap is then repeatedly turned over and stirred. The lime thus combines very advantageously with the earth and humus. This compost, which is often so easily prepared, is productive of the most excellent effects. Lime is also occasionally made into heaps with marshy peat, or with mould which contains a great quantity of undecomposed vegetable substances.

It is indispensable that the lime should be intimately and completely blended and incorporated with the soil, so that every particle of the former substance shall come in contact with some particle of the latter and act upon it. Unless this circumstance is carefully attended to, the ameliorating effects of the lime will be very trifling; the greatest possible care and circumspection should therefore be bestowed on this point. Even when lime has been spread over a soil that has already been fallowed and harrowed, the land must be harrowed once more during dry weather, and then plowed with as shallow a furrow as possible, in order to bury the lime. The best way is to make use of the extirpator, which effectually combines the lime with the soil. The land must receive at least four separate operations of tillage, including those appertaining to the sowings, with the plow and the harrow, or with the extirpator; and all must be performed during dry weather. It is, therefore, indispensably necessary that a dead fallow should be given to land which is ameliorated with lime. It is chiefly from this circumstance that lime produces the effect attributed to it, namely, the destruction of those weeds with which the soil is infested. But if we bestow an amelioration of this nature, without at the same time bestowing all those operations of tillage which this amelioration requires, we have no right to expect the advantages which we might otherwise derive. If too small a quantity of lime is employed, it is not productive of any effect; while on the other hand, if it is applied too profusely, it is injurious, because it then becomes transformed into heaps of mortar and gathers into lumps. When buried by one deep plowing, it forms a calcareous crust beneath the layer of mould turned over by the action of the plow, which crust so much impedes the progress of that instrument, the layer of vegetable mould becomes sensibly decreased. This is frequently found to be the case in countries where lime is very cheap, and where it is used too profusely.

There are various opinions with regard to the quantity of lime which ought to be applied to different soils in order to effect their amelioration. The smallest proportion which has ever been used is sixteen bushels per acre; but I have seen and heard of this quantity being increased to one hundred and fifty bushels, especially on newly-tilled soils. English agriculturists, I believe, apply even more than that quantity. The quantity used ought to depend upon the quality of the lime—that is to say, upon its purity, or upon the quantity of sand or clay that is mixed with it. If the calculation is made according to size or measure, that will be influenced by its compactness at the time of being measured. Besides, the nature of the soil ought also to influence the proportion, since an argillaceous soil

which contains a great quantity of undecomposed vegetable matter, or which is of a marshy nature, although actually dry, can bear a considerable application of lime, and will profit by it; whereas a sandy, loamy soil would be injured by so large a quantity. Lime is not productive of any effect on damp, wet land.—Lastly, we must carefully distinguish between the application of lime which takes place once only, and that which is alternated regularly with stable manure. The former is only used in order to effect that permanent and durable amendment of the soil which may be expected from lime, if applied in the manner and under the conditions which we have prescribed; the latter, on the contrary, is intended to maintain it in fertility. The quantity of lime used to attain the first of these two objects ought to be very considerable, while that which suffices for the latter purpose must be small, and always proportionate to the quantity of manure which is applied to the land; for, in the latter case, it is customary to alternate every three or six years between the use of stable manure and that of lime. There are, however, some countries where lime is applied regularly every third year—that is to say, at every fallow it is applied three or four times in succession before it is again supplied with stable manure. But this course of proceeding exhausts and impoverishes the land to the greatest possible degree.

The most various and contradictory opinions have been put forth with respect to the advantages or disadvantages attendant on the use of lime as a manure, and we can only find our way out of this labyrinth of conflicting statements by means of a theory based upon solid foundations; with the assistance of such a theory, all that at first sight appears problematical, with regard to the subject, will be speedily elucidated. Lime, especially when it has recently been calcined, or is, in other words, what we call quick-lime, absorbs the carbonic acid which is contained in the atmosphere which surrounds it, and subsequently communicating it to the plants, doubtless furnishes them with some nourishment; but this nutrition is very inconsiderable: the property to which it owes the chief power in promoting vegetation is the faculty of decomposing the humus, and inert vegetable or animal substances which it meets with in the soil, and transforming them into nutritive juices adapted to the nature of plants. Hence arise the wonderful effects which it produces when it encounters a great quantity of these substances. Besides, when properly employed, it contributes greatly towards the destruction of weeds. Hence, we see as rich crops derived from a first, and sometimes from a second, application of lime, as would have been produced had the land been abundantly manured with stable dung. Many persons who have not rightly comprehended the cause of the effects produced by lime, prefer it to manure, and have believed in the possibility of doing entirely without the latter; but the total exhaustion of the soil which such a course of proceeding must sooner or later produce, caused them to fly to the opposite extreme, and to regard the use of lime as an application in the highest possible degree prejudicial and dangerous. An enlightened and scientific agriculturist will soon perceive that the use of lime can never supersede that of dung, but that it renders this kind of manure more energetic in its action. Thus, he will profit by the increased fertility which lime bestows on the first crop which succeeds the application of it, and will procure as much as possible of those substances which are adapted for the production of dung, in order to restore to the land, in the shape of stable manure, that substance of which it has been deprived by the lime forcing and increasing the vegetation of the crops to which it was applied. He will likewise know when lime will be beneficial and when injurious; and, if he acts with moderation, will be able to employ lime with much advantage in cases where many persons would be afraid to use it.

The propriety of using lime, in a great measure, depends upon the cost and upon the expenses which will be incurred by the use of it—both of which circumstances are subject to great variation, and depend on locality. When it does not cost more than ten or twelve rix-dollars to bestow a winspel of lime on land, which is the quantity usually applied to an acre, the beneficial effects attending this amelioration will balance the outlay attending it, especially if the land has previously been well manured, but is so infested with weeds that the crops which are produced do not correspond with its fertility, and if a dead fallow is likewise bestowed upon it. In this case, the expenses attendant on such amelioration will

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soon be repaid by the benefits resulting from it. Lime should not, however, be used when any other equally efficacious manure can be procured at a cheaper rate—as calcareous marl, soap lyes, or the ashes of burned peat. Every person can easily calculate for himself what will be the expenses attendant on ameliorating a certain portion of land with lime.

Lime can always be procured at the cheapest rate in those places which are in the vicinity of limestone quarries. It is also less expensive where that marly variety of lime is found, which is moulded into form, in order to be calcined.—One condition essential to this cheapness is, that all the combustible materials necessary for the preparation of it, as wood, coals, or turf, shall be plentiful in the neighborhood of the places where the limestone is found, in order that it may be calcined on the spot, without having to be carried to any distance for that operation to be performed. With respect to the carriage of limestone to any great distance, it must be recollected that when in this state it weighs nearly twice as much as it does after having been submitted to the action of fire, and that thus more labor may easily be lost by the conveyance of this additional weight than would be gained by calcining it at prime cost. Although pure lime is a much more efficient manure than that which is found intermingled with other substances, yet the latter may be used, provided that it does not contain above fifteen parts in a hundred of clay; it will still be very proper for calcination, and the proportion of sand which it may contain without detriment to its ameliorating qualities is even greater. Limestone frequently contains the oxides of metals, which give it a disagreeable color, and prevent it from being used as mortar; this lime is also fit for the improvement of land. The use of lime which contains magnesia is objected to by Tennant, and several other English agricultural writers who follow in his steps; they all pretend to remark that magnesia, deprived of its carbonic acid, is productive of very injurious effects on vegetation.

Opinions are not less divided with regard to the effect produced by lime on meadow land. I do not know of any experiments bearing upon this point which have been made with sufficient precision and attention to all the necessary modifications; but, so far as I am enabled to judge from the results attending this operation in different places which have come to my knowledge, I should think it is one in which we must proceed with all possible circumspection, and which is very likely to be attended with danger if the quantity of quick-lime applied be in any degree liberal. I have been assured that, when spread over dry meadow land in small quantities, this substance is productive of very beneficial effects; but that it is wholly inefficacious on damp, moist meadows. It has frequently been remarked that quick-lime promotes the vegetation of clover and of vetches.

Water which holds a great deal of lime in solution is productive of excellent effects when employed in watering meadow land, either by inundation or irrigation; in the course of this operation, carbonate of lime, in the form of a fine powder, is precipitated over the land.

Lime which has not been calcined is certainly productive of some effect; but, on the one hand, its action is not so evident or energetic as that of calcined lime, and consequently a greater quantity is requisite to produce a similar effect; and, on the other hand, it is difficult to pulverize it sufficiently: it is, therefore, only occasionally used in this state when divided into very small pieces.

The dust collected from roads constructed of limestone and calcareous gravel, is productive of very great advantage when conveyed to the neighboring fields; indeed, there is little or no doubt that this dust contains various ameliorating substances. Very beneficial effects have likewise been known to result from the use of the dust procured from the workshops of marble and stone-cutters.

Even old mortar appears to become decomposed in time, especially if brought into contact with substances in a state of putrefaction. This matter is productive of a very striking effect on meadow land, but one which does not show itself until after a lapse of years.

Marl, as we have already observed, is composed of clay and carbonate of lime, intimately blended together in various proportions. The nature of these constituent parts give to it a double action when used as manure. It acts *physically* by means of the clay, and augments the consistence of loose and friable soils in a durable manner. Secondly, it acts *chemically*, by means of the lime, which renders soluble the humus and the undecomposed matter contained in the soil, and

capable of being taken up by the roots of plants; but this latter action gradually diminishes, and soon entirely ceases. It is necessary to distinguish carefully between these two kinds of action. Marl is productive chiefly of the one or of the other, according as clay or lime forms the predominating ingredient in its composition. If we would have this substance to be productive of the first effect, and that to a very considerable extent, it will doubtless be necessary to bestow a much greater proportion of marl on the soil than would be requisite to produce the latter effect; and, in fact, its physical action can only be produced on light, loose soils; for land which is already too tenacious and clayey in its nature, would only be injured by an addition of marl, at least, as soon as the effects of the lime which it contained had subsided.

The intimate combination of the two component parts of marl renders it more efficacious than clay or carbonate of lime, or even than an artificial mixture of these two substances; because it readily falls to pieces of its own accord, becomes completely pulverized, and thus unites thoroughly with the layer of vegetable earth.

The utility of marl has been known and acknowledged from the remotest ages of antiquity; and this substance has been used wherever the agriculturists were of an enterprising disposition. Nothing but the general ignorance which has prevailed with regard to the actual nature and qualities of marl, has prevented it from being more valued and used than it has hitherto been. The idea formed of this substance is usually associated with that of a fossil of a certain nature and appearance; and hence it happens that as marl exists under an infinite variety of forms and colors, it is frequently not recognized by those who have seen but one species. Frederick the Great, whose ideas in reference to Agriculture were definite and enlightened, but who was discouraged by the want of success which attended those ordonnances which he promulgated on this subject, and which arose from their not being generally understood, sent, in 1750, and during several subsequent years, for a number of laborers accustomed to the digging of marl, and commissioned them to travel over the marches and borders, and seek for this substance; but he received accounts from all of them, that, notwithstanding the most careful researches, they had been unable to discover any. There is, however, an abundance of marl in that country, and of exactly the kind which is best adapted to the nature of the soil. Those persons who were employed to seek for it came from mountainous countries, and in all probability, were only acquainted with stony marl, a species which is seldom found anywhere but in hilly districts. Clay marl, which is the kind usually found in layers beneath the surface of plains, was scarcely known; and in those places where it had accidentally been used, as was the case in the principality of Pretz, in Holstein. The beneficial effects resulting from it were ascribed to the clay; and, therefore, clay which was not of a marly nature was frequently used for the purpose of improving land there; but, as may be expected, without any of the anticipated benefits being derived from the application of it. It is to chemistry that we are indebted for the solution of these apparently contradictory facts.

Another circumstance which has prevented marl from being more generally used, is the abuses which have crept into the practice of marling. In places where its ameliorating effects are known and appreciated, many agriculturists have calculated that marl would prove a cheaper manure than stable dung; and have, consequently, determined to do without the latter altogether; and, therefore, have diminished their stock of cattle, and sold their hay and straw. It may easily be imagined that as soon as the chemical effects of the marl ceased to operate, as must be the case when the land no longer contained undecomposed or insoluble substances, the soil became sterile, and a second marling was incapable of producing any beneficial effects, there being no humus for it to act upon. This circumstance gave rise to the old proverb, that marl enriches the parents, but impoverishes the children. Where a judicious system of cultivation is maintained, this proverb is, however, entirely without foundation; for marl progressively augments the fertility of the soil, by increasing those products which tend to add to the quantity of the dung.

At p. 160, we have spoken of the nature of marl, of its characteristics, its varieties, and the situations in which it is found. We have now, therefore, only to speak of its use and preparation.

As the carriage of this substance is the principal and most expensive part of the operation of marling, it is necessary, in the first place, to endeavor to procure it from some spot as near as possible to the land on which it is to be used; even supposing that at this spot the marl should be situated at a very great depth below the surface, and, consequently, very difficult of extraction, that inconvenience will always be compensated by the proximity. This consideration becomes still more important when it has reference to clay marl, which is to be applied to a light soil, in order to increase its consistency. Fortunately, in most countries where this variety exists, it is generally found extended in a continuous layer a little below the surface of the soil; while calcareous and stony marl is amassed in isolated places, and consequently, has frequently to be brought from a very great distance: but this latter is seldom used in such large quantities, and therefore, this circumstance is not of so much moment.

When there is not any material difference in the distance, those places should be chosen for the raising of marl, in which this substance is situated, at the least depth below the surface, and where the pit that is to be sunk will run least risk of being inundated with water. In flat countries, marl will always be found nearest to the surface at the summits of hills, and especially of those the surface of which is covered with a brown clay. Previous to opening a marl pit, the land should be sounded in various directions, or little holes dug in different places, in order to ascertain whether the marl is of the proper kind, and whether or not it exists in sufficiently thick layers. It is seldom, however, that a continuous bed of marl, uninterrupted by veins or beds of sand, is to be found. But we must not suffer ourselves to be discouraged by this slight inconvenience; for it is very easy, when extracting the marl, to throw aside all that is useless, or to use it in filling up those places where we have dug most deeply.

It is as well to analyze the marl previously to applying it to the land; for it is seldom found to be of a homogeneous nature. Its constituent parts usually vary in different places. The best way of proceeding is, therefore, to analyze that taken from several different places, and then estimate the average composition of the whole from the results of these several examinations; because, in carting and conveying it to the land, it will always become pretty well mixed and amalgamated together. The more sandy the soil which is to receive an amelioration of this nature, the more useful will clay marl be which contains a small portion of lime. This clay may be advantageously applied to such soils, even when it does not contain more than from twelve to fifteen parts in a hundred of lime; but when this is the case, a much larger quantity of marl must be bestowed on the land, if we would have the effects of the lime become evident. The only kind of marl which is not beneficial to these soils is that which contains a great deal of sand. On the other hand, clay marl does not suit argillaceous soils: we must always endeavor to obtain marl for this kind of land which contains, at least, forty parts in a hundred of lime, if not more. Silicious marl, which often contains a great deal of lime, so far from being injurious to argillaceous land, is often peculiarly beneficial. The stony marl, which is found in mountainous districts, is particularly adapted for clayey soils, because it contains a small portion of alumina and a great deal of lime and fine silex.

When we are convinced that the marl is adapted to the purpose for which it is intended, and that it exists in a sufficient quantity, the first step to be taken is to remove the earth by which it is covered. The portions of earth thus taken away may frequently be used to fill up excavations which have previously been made in the vicinity; but where this cannot be done, they must be so disposed that they shall not fall back into the pit, and yet shall be sufficiently near to admit of their being thrown into those places whence all the marl has been extracted, and which we wish to fill up. As all the operations connected with the raising of marl ought to be executed, as far as possible, by the task or job, this one should be included, and calculated by fathoms or cubic yards. If the earth has only to be conveyed a short distance, wheel-barrows may be used for the purpose. Sometimes it is merely necessary to throw it up on the edge of the excavation by shovels.

It is sometimes necessary to uncover the whole surface of the marl pit, while in other cases it is better to open only a portion of it. This is especially the case when it is not intended to dig deeply, and when the places whence the marl has

been extracted are to be filled up by the earth which covers those portions yet untouched. The operation may be carried on in this way from the foot of a hill, containing marl, to its very summit. But when it is the intention of the agriculturist to excavate to a greater depth—which he will often be the more disposed to do, from the circumstance of his finding the marl more homogeneous and calcareous the deeper he penetrates—it will then be necessary to uncover the whole of the pit, in order to be able to work with greater facility, and to avoid the danger of the earth falling in. An extent of eight perches in length and six in width forms a very fair-sized marl pit; but there have been cases in which this extent has been doubled.

Every marl pit must be provided with an entrance and an exit, in order that the wagons may pass through it, and not be obliged to turn; and both these roads must be gently inclined, in order that the descent and ascent at the entrance and transit may be effected with as little difficulty and labor as possible.

In extracting the marl and conveying it to the land to which it is to be applied, as equal a proportion as possible should be established between the number of laborers employed in digging and loading the wagons, and the teams for transporting it, so that neither shall have to lose time by waiting for the other. This proportion will, of course, be varied by the distance to which the marl has to be conveyed, the depth from which it has to be extracted, its tenacity, the state of the temperature, and the quantity of water which is collected in the pit. Matters must be so arranged that there shall always be a cart, wagon or wheel-barrow in the manure pit ready to be loaded, but which shall not have to wait. The laborers employed in digging and loading should not be allowed more time than is absolutely requisite to enable them to dig out sufficient marl to load the wagon. If the distance is short, and the operation progresses rapidly, one set of laborers must be employed in digging while the others are loading.

When the distance is considerable, and the teams cannot return so quickly as they would if they had a shorter space to traverse, the number of laborers must be diminished, or more teams must be employed. This matter may easily be regulated by reference to locality, &c. Those persons who find that they have fewer laborers than they have teams, should cause the marl to be conveyed to the most distant fields; while those who find that they can command a greater number of laborers than of teams, can have the marl carried to those portions of land in the immediate vicinity of the marl pit.

When the operation of marling is performed by persons who undertake it by the task or job, they sometimes furnish the wagons and teams; while, at other times, their employer finds them. In the latter case, when the greatest distance which the marl has to be conveyed does not exceed from eight hundred and forty to nine hundred and sixty Rhenish feet, the sum paid for a wagon containing eighteen cubic feet will be nine pence. If the employer finds his own drivers, as well as his own teams, he will not have to pay more than six or eight pence. I pay about a shilling here for such a load. It is, of course, understood that this price supposes that there is no particular difficulty attending the extraction of the marl, and that this substance has not to be dug from any great depth. This is the usual way in which these matters are arranged when the plow horses are used in conveying marl, and when the agriculturist does not choose to entrust his cattle to strange laborers, but rather that they shall be driven by their own carters and drivers.

Local circumstances can alone enable us to decide on the expediency of keeping or hiring horses expressly for the performance of this operation, or making use of those teams which are kept for the performance of the various operations of tillage when not otherwise employed. If it is intended to conduct the operation on an extensive scale, the former course is unavoidable; for, if the latter were adopted, the marling would only proceed when the laborers and teams were not otherwise employed. Whenever teams are kept expressly for the purpose of conveying marl, it will also be necessary to keep laborers solely for the performance of that work.

The kind of vehicle used is generally adapted to the cattle which are employed. When horses are kept expressly for this purpose, tumbrels drawn by one horse will be found to answer best; and, in time, the animals become so accustomed to their duty that one driver will suffice for two or three of these carts;

but, where the ordinary teams are used, wagons drawn by two horses are preferable. I am no advocate for the use of teams of four horses, unless the distance is very considerable, or the roads are heavy. Where such is not the case, two horses will draw almost as much as four. I could never make a team of four horses draw more than a load of twenty-five cubic feet at most, while two horses will usually draw a load of eighteen or nineteen feet. A Rhenish cubic foot of marl, in its ordinary state of humidity, weighs from a hundred to a hundred and three pounds, Berlin weight.

It is seldom that any marl, and especially clay marl, is homogeneous in its nature throughout the whole extent of the pit. In some layers or particular spots it will be found to contain an amazing quantity of lime, while in others it contains but very little. Those who are not sufficiently accustomed to it, and unable to distinguish these variations in its constituent parts by examination or touch, will do well to have recourse to a superficial analysis. In general, the deeper we penetrate the more homogeneous does the marl become; veins or beds of sand are often found intersecting it. This sand is sometimes of a calcareous nature, and is then exceedingly beneficial to clayey soils, or may be advantageously mixed with mould and peat. But even if no use can be made of the sand or clay thus found, and which seldom contains much if any lime, it must still be separated from the marl and got rid of; and in this case the best course of proceeding is to throw it into those excavations whence no more marl is to be extracted.

The thickness and nature of the layer of marl can alone enable us to decide on the expediency of excavating to any great depth. In general, the farther we penetrate into the layer the more calcareous is it found to be; but then the expenses attending the operation, the labor and the danger, will be considerably increased, and even doubled, unless very great precautions are taken. Marl extracted from a great depth will have in the first place to be thrown on a kind of scaffold before it can de carried to load the wagons, hence both the labor and expense will be doubled. Unremitting attention must likewise be bestowed on the whole progress of the excavation, to see that the walls do not bulge in the slightest degree, or the workmen deviate from the perpendicular; for, should either of the sides of the pit fall in, very serious mischief would be inevitably occasioned.

When the pit is excavated to any great depth, the workmen frequently have to contend with springs of water, which rise from the surface of the soil or filter through the veins of sand; and it not unfrequently happens that this influx of water is so great that it becomes necessary to abandon the pit altogether. Hence, we seldom find marl-pits excavated to more than from six to twelve feet below the surface. Some agriculturists have, however, extracted very good marl from twice that depth.

The quantity or proportion of marl that should be supplied to a field varies greatly, being influenced by the nature of the substance itself, of the soil to which it is applied, and the end which is to be attained by its application. The more calcareous marl is, the greater will be the effect produced by it, and, consequently, the smaller the proportion which it will be necessary to supply. A marling in which from twenty to twenty-five loads, each containing eighteen cubic feet, is allowed per acre, is considered to be sufficiently abundant for almost any purpose; this species of marl ought to contain at least sixty parts in a hundred of lime: it is used in the amelioration of clayey or argillaceous land.

The more that clay predominates in marl, the greater must be the quantity of that substance applied to any portion of land, especially if that land be of a sandy nature; because, independently of the chemical amelioration which it receives, the soil will thus likewise derive a durable physical improvement. The marl is spread over the whole surface of the field in a layer of an inch thick, which takes about one hundred and twenty such wagon loads as we have been speaking of per acre. In most countries, when the practice of marling is first adopted, quite as much marl as has just been stated, if not more, is used; and there is no doubt that a durable improvement of the nature of the soil is thus produced. But I have always observed that in proportion as the agriculturists become more acquainted with the details and results of this operation, and practice it on a more extensive scale, they become more economical, and reduce the quantity of marl above mentioned to sixty, and sometimes even to forty loads per acre; and

they find that this marling is productive of the requisite effect: the only difference is that the effect is not so durable, and does not last more than from ten to twelve years. But then much greater advantages are derived from a repetition of the operation, after a lapse of twelve or sixteen years, than would have been obtained if a very abundant manuring had been bestowed in the first place. Most persons have, therefore, been led to prefer the application of marl in small quantities, frequently renewed. Sixty loads of marl, which contains about twenty-five parts in a hundred of lime, is the usual proportion; and the layer which this amelioration will add to the soil is about an inch thick. If the marl contains much less lime, a considerably larger quantity must be employed if we would have it to be productive of equally satisfactory results; but marl containing fewer than twenty-five parts in a hundred of lime is only calculated for sandy soils.

The differences in the quantity of marl used, and in the consistence and nature of the soil, will serve to explain all those apparently contradictory results which have attended experiments on repeated marlings. A second or a third marling has sometimes not only been unattended with any good results, but has even been productive of baneful consequences; while, at another time, a second marling has been attended with more beneficial results than the first. In the former case, the soil already contained an abundance of all that the marl could bestow; but it had not been properly manured, and common marl is incapable of restoring humus to an exhausted soil. If the marl applied was clay marl, it is possible that the evil arose from the soil being of an argillaceous nature, and thus becoming saturated with clay, and actually deteriorated. In the latter case, the land had been well manured, the physical properties of the marl were adapted to the nature of the soil, and thus the consistence of the latter was sensibly ameliorated. In districts where the land is regularly marled at certain intervals, and a sufficient quantity of manure is also applied to it, it is generally considered that, when some particular weed or weeds choke the crops, infest the soil, and shoot up luxuriantly all over it, this land requires marl rather than dung. Whenever this is the case, the operation of marling, which must of necessity be accompanied by a dead fallow, not only destroys the weeds, but fertilizes the soil much more than manure would do; for the vigorous vegetation of the weeds tends to prove that the soil contains an abundant supply of those juices which are necessary to the nutrition of plants, but that these juices are more adapted to weeds than they are to cereals. The chemical action of the marl, in all probability, totally changes the nature of the humus.

But, in those countries where the land is frequently and regularly amended with marl, only a very moderate quantity of that substance is applied. It is seldom that more than from twenty-five to thirty loads of argillaceous marl are bestowed on an acre of sandy land; or that more than ten loads of calcareous marl are applied to an acre of argillaceous land.

There are various opinions with regard to the duration of the effects produced by marling, and, in point of fact, this duration must of necessity be influenced and varied by circumstances. A considerable addition of argillaceous marl will afford a durable amendment of the physical properties of a light sandy soil, and will render it capable of bearing more luxuriant and abundant crops than heretofore, provided that it is properly manured. The chemical effect of marl will be perceptible during a period of from ten to twenty years, according to the quantity of that substance which has been applied to the land. The effects of calcareous marl on a clayey soil can seldom be said to endure more than ten or twelve years. It is according to a calculation founded on this proportion, that in many districts farmers are repaid the expenses incurred by those marlings which they have bestowed on the land during the time it has been in their possession, but of which the expiration of their lease has prevented their reaping all the benefits. Thus, for example, if a farmer has enjoyed the benefits arising from this operation only for five years, he is repaid 7-12 of the expenses; but if he has enjoyed them for nine years, he only receives 3-12.

In general, the improvement resulting from marling goes on increasing to the third year, provided that during this period the land is properly manured; and after that time it progressively declines. But this result depends in a great measure on the disposition of the marl to become thoroughly divided and to fall to powder, since it does not produce its beneficial effects until it becomes completely

blended and incorporated with the soil: this is the reason that it is so imperatively necessary to bestow all the proper operations of tillage on land to which marl has been applied.

When horses are kept expressly for the performance of this operation, as is the case in all those places where marling is practiced to any great extent, the work may be carried on without interruption during the whole year, so long as it is not impeded by alterations of temperature, or by frosts which have penetrated deeply into the ground. But where the marl has to be conveyed by the ordinary farm teams, and sometimes even by oxen, the operation can only be performed during the latter end of autumn, the winter season, and the intervening period between the spring seed time and the harvest. Marl conveyed to land during winter, or at the latter end of autumn, acts very promptly on account of its being completely divided and pulverized by the cold and frosts. When the ground has not become too much hardened by frost previous to being covered with snow, it is worth while to remove this latter substance from those places where we wish to dig, and to break the frozen parts, and convey the marl to the land over which it is to be spread on sledges. Marl which is not carried to the land until winter is nearly or quite gone, seldom becomes sufficiently pulverized to be minutely and intimately blended with the soil, even though it shall have received repeated plowings, and consequently, is productive of little or no effect on the first crop of autumnal corn. The English system of marling is seldom used here; they insist that, previously to its being buried, the marl shall be spread over the soil, and suffered to remain there, exposed to the burning sun of two summers, and the cold and frost of one winter. If, as is generally the case, the marl is applied to the fallow after the first plowing has taken place, it will be necessary, in order to follow out this practice, to bestow two successive dead fallows upon the land. But English agriculturists likewise marl land which is at rest, or laid down for the production of artificial grasses; which then shoot up luxuriantly, and yield an abundant crop of pasturage.

Marl which has been put on the land before the commencement of winter, and suffered to remain there until the middle of summer, will generally be pulverized sufficiently to be thoroughly incorporated in the soil by repeated plowings, harrowings, and rollings. But when this substance has not been conveyed to the fields until spring, it seldom becomes sufficiently pulverized and reduced, and remains in the soil in lumps and clods after it has been turned in. That which has been spread over the land before the commencement of the winter, produces an immediate effect; while the effect of that which is not spread until the spring, is very tardy, and, in fact, is scarcely perceptible during the first year.

Some agriculturists who wish to obtain immediate benefit from the marl which they apply to their land, sow crops of spring corn upon it, as barley, oats, or buckwheat; but, in general, with little success. A carefully tilled, complete, dead fallow is indispensably necessary to ensure the good effects of marl, and to render them speedily evident.

It is almost superfluous to state that the marl ought to be spread over the land as carefully and equally as possible. After this has been done, the land should be well harrowed in dry weather; and if any lumps of marl still remain undivided, the roller should be passed over it; and subsequently, when the marl has been moistened with rain, and again become dry, the harrow should once more be used. The first plowing may then be bestowed, which must be as light as possible. Afterwards, three other plowings should be given, and each succeeded by a harrowing, and then the intimate blending of the marl with the soil may be left to Nature. If the marl still continues lumpy, this combination cannot take place, nor will that substance become incorporated with the soil until after the lapse of a considerable period. Those portions of marl which are not mixed with the soil in the form of a fine powder, are not only wholly inefficacious, but positively injurious to vegetation.

The expenses attendant on marling must necessarily vary considerably under different circumstances and in different localities. The labor attending the extraction of this substance, and the loading of the vehicles in which it is to be conveyed, will depend, in a great measure, upon the depth from which it has to be raised. The tenacity of the marl also, and the quantity of water with which the laborers have to contend in the pit, cannot fail to have considerable influence

on the expense of the operation. When the marl can be carted and carried away as soon as it is detached, the usual price of a load of eighteen cubic feet is from six to eight *deniers*.* In Holstein, one shilling and six pence is usually paid for the same quantity; and for this sum, the laborers are expected to get the marl, fill the carts, and spread it over the land, provided the distance of the fields from the pit admits twenty-five loads per day being carried, and they are found in teams and vehicles. I pay one shilling for the cartage of such a load, and find teams, and mattocks, and drivers: at this rate, the laborers are well paid.

The expenses of carriage depend entirely upon the distance. It not unfrequently happens that calcareous marl is conveyed to argillaceous land, which is at least a mile distant; and where this is the case, one team cannot convey more than two loads per day, and sometimes not more than one. The operation of marling will then prove an expensive one, and will often cost even more than an amelioration of lime. Clay marl can only be used in the immediate vicinity of the place where it has been extracted; attempts are therefore made to procure it from each field, or from the nearest possible spot. When the distance is once known, it is easy to calculate the number of loads which one team can convey in the course of a day.

The following will be found to be the usual amount of the expenses attendant on the marling of an acre of land.

	Rix-dol.	Gros.
To getting and filling 60 loads of marl, at 8 deniers per load	1	16
Two horses, which will in general be able to convey the quantity requisite for an acre of land in 3 days, at 8 gros. each per day	2	0
Spreading the marl over an acre of ground	0	8
Cost of opening the marl-pit, and other incidental expenses	0	6
Wages of the driver, at 6 gros. per day	0	18
	5	0

It must be borne in mind, that in this estimate all attendant circumstances are considered to be favorable. In proportion as the difficulties of the operation increase, so will the expenses be augmented. During the short days of winter, not more than fifteen loads per day can be carried; while, in the summer, when the days are long, as many as twenty-five can be conveyed with ease. In the former season, therefore, the daily work done by the teams must be estimated at a lower rate, in order that the valuation may be increased in the summer.

I knew a case in which, in order that the marling of a field situated at a considerable distance from the farm buildings might be executed as quickly and with as little delay as possible, vetches were sown on those portions of land which had received this amelioration; and the teams employed in conveying the marl were thus fed: they were left there night and day, and tethered with cord to prevent them from treading down the plants beyond the space immediately assigned them.

The use of marl is always attended by evident and beneficial effects, especially when argillaceous marl is applied to a sandy soil; and advantageous results have been obtained even when after several years of rest the land has appeared so exhausted and sterile as scarcely to be worth the trouble of sowing it. Nevertheless, this effect is only relative, and by no means absolute. The produce is increased from two and a half to five bushels per acre for several crops, and especially at the third crop; but it subsequently declines progressively, unless the land is laid down to rest for a considerable period, or manured with stable dung. But the effect of marl is far more evident and beneficial on land which still contains both succulency and humus, which is manured from time to time, and laid down to grass before it becomes exhausted: in this case ten bushels of produce per acre are frequently obtained from a field which, had it not been manured, would not have yielded more than four bushels.

The effects resulting from this amelioration will be rendered greater and more durable if an addition of stable manure, ever so small in quantity, be combined with it. When the land is not in very good condition, it is as well to bestow four loads of dung on it, either when it is marled or in the following year at the latest. Should the land, however, be tolerably fertile, it is to be feared that

* 12 deniers make 1 groschen, and 24 groschen 1 rix-dollar, which, in English coin, is worth from 4s. to 4s. 3d., and in some parts of Germany even as much as 4s. 6d. According to this calculation, therefore, the expenses attendant on the marling of an acre of land will be from £1 or £1 1s. to £1 2s. 6d.

such a course of proceeding would have the effect of laying the corn; two or three crops of cereals may, therefore, be raised after the marling has taken place, and then an amendment of stable-manure be bestowed on the land. But so soon as this latter appears to be necessary it should be given, otherwise the soil will become more exhausted than it would have been had it not been marled, and it will be a very difficult matter to bring it into good condition again.

It is likewise advantageous to make use of marl, together with peat or mould, in the form of a compost: this mixture is productive of prompt and sensible effects even on an exhausted soil.

In England the attempt has been made, and with great success, to bury a crop of green buckwheat as manure. Spergula, or spurry, is equally well adapted for this purpose.

Of all this class of ameliorations, marling is the one which can in general be effected with least difficulty; it is one of the most durable, and, if we except a very few others, is that which is attended with the greatest advantages.

There is also another earth which is productive of astonishing effects when employed as manure, which contains a considerable proportion of lime, and is besides very rich in humus. It is found in those low situations which have in all probability once formed the beds of rivers, or at all events have been covered with water. This earth is of a bluish color, and resembles a very friable poor clay; it is soft to the touch, and is frequently intermingled with small shells. It is seldom found immediately under the vegetable soil; a sterile layer of clay usually intervenes between the two, which must be broken through and removed before we can reach this substance. I have analyzed a portion of this kind of earth which was obtained from the marshes of Oldenburgh, and the following were found to be the proportions of its constituent parts:—

Fine sand, one-half of which could be separated by washing and the other by boiling	36
Carbonate of lime	14
Humus	5
Fat clay	44
Gypsum	1
	100

The humus was evidently of an animal nature, and when burned emitted a fetid odor. I have no doubt that this fertilizing and ameliorating earth might be found in many places where its existence is yet unknown; it is composed of the residue of plants, fishes, and testaceous or shelly matters, in a greater or less degree of attenuation, deposited among fine sand, and which have subsequently been covered by depositions of those matters which have been washed down from the elevated spots by rain or by currents of water. It is well worth while to take the trouble of digging and searching for this substance in all those valleys which appear to have been once covered with water.

The following is the manner in which this earth is usually extracted:—

In the first place, a pit or excavation, of about six feet in width and twelve in length, is opened; the layer of vegetable soil is thrown up on one side, and that of virgin clay, which is usually about four or five feet in thickness, on the other. This ameliorating earth which is found underneath is then extracted, and the excavations in search of it are carried to as great a depth as they can be without danger; the pit or opening is then extended, and those places whence the earth has been extracted are filled by throwing into them the clay and vegetable soil before mentioned; and so the operation is carried on until a sufficient quantity of this earth has been obtained.

This earth is, in itself, perfectly sterile, at least when first extracted; but after having been mixed with the soil and carefully tilled, it renders the latter exceedingly fertile. Land which has been thus ameliorated is distinguished for a considerable period by its wonderful fertility.

A knowledge of the advantages resulting from the use of gypsum (sulphate of lime) is by no means a discovery of recent date. We find many traces in the annals of antiquity of its having been known and used in isolated countries and places, but its use as a manure was but very partially introduced until about the middle of the eighteenth century, when Herr Mayer, a clergyman of Kupferzell, in the principality of Hohlenlohe, noticed it in a correspondence with Count Von Schulenberg, of Hehlen, in the electorate of Hanover, as having been long used in the neighborhood of Gottingen as a manure. The reputation of gypsum was

widely diffused by the writings of Meyer. Tscheffeli, the zealous Swiss agriculturist, soon afterwards tried experiments with it, and the success with which they were attended introduced the use of it into Switzerland. An account of the experiments made by Tscheffeli, as well as those of other celebrated agriculturists, to ascertain the properties and use of gypsum, will be found recorded in "Les Memoires de la Societé Economique de Berne." Schoubart and Kleefeld were the first German agriculturists who made known the beneficial effects of gypsum when used as a top-dressing for clover. But several persons exclaimed against this practice; and after making, or pretending to make, various imperfect experiments, to say the least of them, declared this substance to be wholly inefficacious, if not injurious. This question was discussed for a long time, without arriving at any satisfactory conclusions.

Among the opponents of gypsum were all the proprietors of salt works, who feared that if it came into general use, they should no longer find a ready sale for the residue of their manufacture, which had previously been used in all the neighboring districts. On the other hand, the use of gypsum as a manure soon spread among the agriculturists of France, especially in the vicinity of Paris, whence it extended to America. From the very first moment that it was made known in this latter country, large cargoes of it were imported from Montmatre.

The use of this substance was more rapidly extended in the provinces of North America than in any other part of the world; and nowhere has it found fewer partisans than among the agriculturists of England. In my work on English Agriculture, I have given as a reason for this neglect the quantity of calcareous particles which the soil of most of the counties of England contains, either naturally or artificially; but I was wrong in so doing, for the effect of gypsum is equally as sensible on land which has been well supplied with calcareous particles, as it is in those counties where there is a great deal of gypseous rock, and where, to all appearance, the soil contains a considerable portion of gypsum. Perhaps the prejudice which exists in England against every thing and every discovery that is introduced by France or even by Germany, may have in a great measure tended to render the agriculturists of that country blind to its utility. They seem inclined to tolerate and adopt only the discoveries and practices of the Americans.

It cannot be denied that many of the experiments made with the view of verifying the effects of gypsum as a manure, have been attended by the most contradictory results; and it is an undoubted fact that its effects are modified by various circumstances that have not, as yet, been sufficiently inquired into. The effects resulting from the use of this substance are much greater on dry soils than they are on those which are moist and damp; and more sensible in dry than in rainy or wet weather. A moist state of temperature retards the effects of gypsum, and sometimes appears to suppress them altogether, especially if the gypsum has been calcined. This substance is not productive of any effect on an exhausted soil which contains but little humus. Its influence on the vegetation of some plants is very trifling, while on others it exercises a marked power. Those plants on which gypsum appears to produce the most sensible effects belong to the papilionaceous and cruciform orders. There is no doubt that gypsum acts upon the plants themselves, and, consequently, is more efficacious when its dust attaches itself to their leaves and remains there for a considerable time. I received a very striking proof of this effect in a case where the wind had carried the dust of powdered gypsum over one side of a hedge of white-thorn, which, in about eight days, began to put forth rich and luxuriant foliage; while the other side, which had not come in contact with this fertilizing dust, remained very much behind. But gypsum does not act solely in this way, as I was once inclined to think that it did; but I have since been convinced, by recent experiments made on the subject, that it likewise acts on the soil. In the autumn of 1808, we spread this substance over an acre of land, which was carefully marked out and sown with rye. In the spring of 1809, white clover, intended to form a pasturage, was sown on this field, which was considerably impoverished; this clover failed almost everywhere, excepting on the acre ameliorated with gypsum, where it was so thick and luxuriant that this spot was eminently distinguished from all the surrounding land.

We have already stated the manner in which gypsum acts upon the soil. In

all probability it enters into a reciprocal but very slow action with the humus.—This latter substance decomposes the acid portion of the gypsum, and thus produces carbonic acid, or some yet more compound substance. It is not, as yet, known what is the nature of the matter thus formed, and, in all probability, never will be, on account of the rapidity with which it decomposes. It is probable that the sulphur, thus deprived of oxygen, blends with the lime and with a portion of the hydrogenated carbon; and that this combination produces the fetid odor which is disengaged when gypsum is combined with substances in a state of putrefaction. From all appearances, we are led to believe that this carbonic acid and its new combinations are peculiarly adapted for the nourishment of certain plants. Hence it happens that the effect of gypsum is proportionate to the quantity of humus, or other substances in a state of putrefaction, which it meets with in the soil over which it is spread.

Gypsum is chiefly used in the cultivation of clover, or other plants of a similar nature, and sometimes also for vegetables. As it is productive of a sensible effect on those of the cabbage kind, I am inclined to believe that it would also be beneficial to rape; but I do not think there are yet on record any well-attested experiments calculated to demonstrate the truth or fallacy of this supposition.

Gypsum is used both in a calcined and an uncalcined state, without the effects produced by it appearing to be very different; unless, indeed, a heavy rain falls immediately after this substance has been spread in the former state, when the powder will be agglomerated, converted into hard stony lumps, and rendered wholly inert. The most important point to be attended to is to see that the gypsum is powdered as fine as possible; it should be literally reduced to dust, if we would have it productive of the most beneficial effects; this is a very difficult matter when the gypsum has not been calcined, but gypsum which has been submitted to the action of fire may easily be reduced to powder.

In some places this pulverization is effected at a very small expense by means of water mills; but, in situations where no such mills exist, recourse is had to various other contrivances. The gypsum is then placed in mortars or troughs, and pounded with pestles or other instruments used for the purpose of bruising millet or making oil of rape, or broken in pieces by means of a grindstone.—When it is thus pounded, it is passed through a sieve, and those parts which do not appear to be sufficiently pulverized are pounded or ground afresh. After having been thus prepared, it must be kept in a dry place, in order that it may not absorb that humidity which would tend to restore to it some portion of its former adhesiveness.

A calm day should be chosen for the purpose of strewing gypsum, when there is little wind, and when the dews have been heavy; the time chosen for the performance of this operation should be late in the evening, or early in the morning, especially when it is used as a dressing for clover, because at these times the dew on the leaves of the plants will cause it to adhere to them. This kind of amelioration should never be applied in windy or in rainy weather. Gypsum seldom appears to be productive of more beneficial effects than when used as a top-dressing for clover, the vegetation for which is already sufficiently advanced to enable its leaves to cover the soil; this operation ought, therefore, generally to be performed about the beginning of May. Some persons have, however, derived advantage from strewing it over the young clover plants in autumn. It is not unfrequently used as a dressing after the first cutting has taken place, and with the view of accelerating and increasing the vegetation of the second; and where this has been the case, the second cutting has been found to yield far more than the first, and which it would not have done under other circumstances. The quantity of gypsum requisite for an acre of land varies from one to two bushels. When it is properly pulverized, the former will be sufficient; but if such is not the case, a larger quantity must be applied.

All the experiments which I have yet been enabled to make, or of which I have had an opportunity of watching the progress or inquiring minutely into, tend to convince me that gypsum is productive of evident and beneficial effects, unless these are counteracted by heavy rains, variations of temperature, or some negligence or inaccuracy in the experiment. I do not, therefore, hesitate to recommend the use of this substance as a means of increasing the vegetation of clover, and rendering it both vigorous and luxuriant, wherever it is obtained suffi-

ciently cheap to make the expenses attendant on an amelioration of a bushel and a half per acre not exceed one rix-dollar and eight groschen, or five shillings and eight pence in English money. If the land is in tolerable condition, although not excessively fertile, we may expect to obtain from six to eight quintals of clover from it, beyond what it would have yielded without the intervention of gypsum; it being, of course, understood that the plants were pretty thick, since gypsum cannot create them where they do not exist. If, however, there is one plant on each square foot of land, the effect of the gypsum will be such that, at the time of flowering, the clover will completely cover the soil. But, on the other hand, should the clover be very thick, and the soil sufficiently rich and fertile to admit the plants shooting up luxuriantly without any extraneous aid, a dressing of gypsum would only produce an excess of vegetation, and tend to dispose the plants to rot; and, where such is the case, it is as well to abstain from the use of this substance.

All the experiments that have hitherto been made seem to prove that gypsum has little or no direct effect on gramineous cereal plants when spread immediately over them; but it is the unanimous opinion of every one who has had the opportunity of observing this point, that the stubble of a clover crop which has been dressed with this substance produces much finer cereals, and especially wheat, when turned in as manure, than are ever obtained where the gypsum has not been used. This effect appears to have been produced by the tendency of the gypsum to augment the vigor and succulency of the roots and stems of the clover, and thus to increase those portions of its residue which this plant leaves both on and in the soil. It is a well known fact, that the vigor and fineness of corn crops succeeding to clover is always proportionate to the vegetation of that plant. Thus then, the use of gypsum is indirectly, if not directly, favorable to cereals; it is also productive of still greater advantages by the increase of fodder, and likewise of dung, which it procures.

This species of manure, which, from the smallness of the quantity of it that it is necessary to apply to the soil, may be procured from great distances without much inconvenience or expense, is then a very valuable one: but it must not be forgotten that no effect can ever be expected from its application to exhausted land.

Gypsum leads us to speak of other salts which may be employed for the purpose of ameliorating the soil. But, if we except the residue of salt works, these substances are seldom used for this purpose, on account of their being in general too expensive.

The experiments hitherto made with regard to the use of these salts have been for the most part limited and partial. Most of them, and especially those which relate to common salt (muriate of soda), have been attended with the following results:—When applied to the soil in too large a quantity, this substance has completely checked vegetation; but when the salt has been washed by heavy rains, and perhaps partially decomposed, it gives a degree of strength and vigor to the vegetation of the succeeding years. If a small quantity of it is spread over a very rich soil, the effect produced by it is very sensible, but of short duration; on the other hand, if this small quantity is spread over an impoverished soil, no effect whatever is produced. This mode of ameliorating land is therefore seldom practiced even in the neighborhood of salt mines, where it can be procured at a very low price. But, on sea-coasts, the effects produced by salt water on vegetation become strikingly evident; this is the reason that salt marshes are preferred to others for the pasturage of cattle. The grass which grows on such places is eaten with avidity by all kinds of cattle, whether as pasturage or in the form of dry fodder; and it is peculiarly wholesome and nourishing to them. But even on the sea-coast the salt is speedily carried away from the soil by rain or other kinds of moisture: indeed, when land of this nature is analyzed, few vestiges of saline matters are to be found in it.

The experiments made with regard to the use of saltpetre (nitre, or nitrate of potassa), employed in very small quantities, have been attended with much more evident and sensible results than those arising from the use of common salt: but in ordinary undertakings, this substance is not available on account of its being so very expensive; nor should we have spoken of it at all had not this circumstance tended to demonstrate the fertility of those soils which spontaneously pro-

duce nitrate of lime. We must, however, pause to observe that many soils are supposed to contain saltpetre which really do not possess a particle of it; that whitish substance which is observable on all soils containing a considerable quantity of mould, and which is so often mistaken for saltpetre, is neither more nor less than a *lichen* (*lichen humosus*) which such land produces, and which certainly is a proof of fertility. That portion of saltpetre which the soil produces spontaneously is speedily washed away by rain or moisture; hence this substance is rarely found when land is analyzed; it is much more frequently found in the plants which have sprung from such land; but it does not appear to form an essential portion of them, but rather to have entered into their composition accidentally, and to exist there as a foreign body: this is the case, for example, in wild beet-root.

It is not worth while to enter into any dissertation on the subject of the neutral salts.

Latterly, the metallic salts, and especially green vitriol, or sulphate of iron, have been considered as well adapted for the improvement of land. There was a time when this substance was regarded as exceedingly prejudicial to vegetation, and land impregnated with it was justly considered to be sterile. It is only within the last few years that theory and experience have combined to teach us the value and utility of green vitriol. When the importance of oxygen in the promotion of the germination of seeds and the early development of plants was first perceived, it was deemed possible to enclose this matter in oxides, acids and acid salts; but positive effects were only obtained from those oxides and acids which were easily susceptible of decomposition, and allowed their superabundant oxygen to disengage itself. After having made various experiments in order to elucidate this point, the influence of acids and of acid salts on the germination of plants still appears to me to be very doubtful.

In the experiments on the action of green vitriol, or sulphate of iron, dissolved in water and used as a manure, the results appear to vary exceedingly; some persons have not been able to discover that it produced the slightest effect; others have found it injurious: while a third class have declared that they have derived considerable benefit from the use of it. In most of those experiments which I have had an opportunity of investigating, the quantity of this solution that was used, and the extent of land watered with it, have been by no means accurately defined; it is nevertheless very important that both these points should be ascertained, and unless we are acquainted with them it is quite impossible to explain the causes of those contradictory results.

Experiments undertaken by accident, and which tend to determine the ameliorating powers which some vitriolized fossils possess, have given to this subject an importance, in a practical point of view, which it would not otherwise have possessed. In England a species of peat strongly impregnated with vitriol has been found; and in Germany, in the estates of Reibersdorf, belonging to the Count d'Einsiedel, a mine of highly vitriolized coal has been discovered, both of which substances form very active manures when used in small quantities.

From the results of experiments made with these substances, it appears evident that vitriol, when combined with coal, exercises a powerful influence on vegetation. Possibly the action of light and air effects the decomposition of the sulphuric acid, the oxygen of which combines with the carbon and forms carbonic acid, or some other substance equally favorable to vegetation. Nor is it altogether improbable that, by means of the hydrogen which is united with the coal, the sulphur and the coal itself enter into combination, and contribute to accelerate and strengthen vegetation. Pure green vitriol, or sulphate of iron, can combine in the same manner with the humus which it meets with in the soil, and is then productive of the most beneficial effects. Farther light must be thrown on this subject by the medium of patient investigation and carefully conducted experiments, ere we can venture to determine whether this substance is really capable of ameliorating land, and in what proportions it should be employed.

The great and incontestibly good effects resulting from the use of coal and peat impregnated with vitriol, ought to induce all persons to have it in their power to dig in search of these substances, and to use them for the amelioration of land.

When vitriolized coal is used as a manure, it is first reduced to powder, and

then spread over the land after the last plowing or sowing, but not buried. The quantity of this substance applied to the land must be regulated with the greatest circumspection and care. When used too plentifully, it is injurious; and if it is suffered to remain on the soil in heaps only for a few days, every trace of vegetation disappears for several years from the spots where such heaps have stood. It ought, therefore, only to be unloaded on the roads, or on the edges of land where little or nothing is sown. When the soil is of an argillaceous or calcareous nature, from 30 to 36 bushels per acre may be applied to it; but not more than from 15 to 18 bushels must be bestowed on a calcareous soil.

The question of the ameliorating or non-ameliorating effects and properties of acids is a theoretical rather than a practical point, since it rarely happens that we are able to make use of these substances. Nevertheless, we will pause to make a few remarks on this subject.

In theory, the use of acids has been recommended for the purpose of ameliorating the soil on account of the oxygen they contain, which is in itself highly favorable to vegetation; the fact that their decomposition, when in the soil, is too independent of external causes, appears to have been wholly overlooked.

Those experiments which have been made with acids have been attended with very contradictory results: it is astonishing that the talented men by whom they were conducted should have omitted to inform us of the nature and composition of the soils to which they applied the acids. Various accessory circumstances tend, however, to induce the belief that it was only on calcareous soils that sulphuric acid was productive of beneficial effects, and this was the only acid with which experiments were made; its good effects are easily explained by the fact that on land of this nature sulphuric acid produces gypsum, and causes the evaporation of the carbonic acid. Those soils to which it was prejudicial doubtless contained little or no lime.

Lastly, we must not omit to notice ashes as being one of the most active manures, as well as one which is very frequently used. When thoroughly burned, ashes are composed of earths and potash, to which are sometimes added metallic oxides and different salts. Lime is always the predominating earth which enters into their composition, even when the plants whence they are derived have not sprung from a calcareous soil.

It cannot be denied that potash contributes greatly towards the amelioration of land by its decomposing power; but, in general, ashes are not used until they have been lixiviated; notwithstanding which, they are still productive of considerable effect, although not so great as would have been derived from their use if they had not been submitted to that process. Ashes must contain some peculiar and hitherto undiscovered matter, which gives to them an action so much more efficacious than that of an equal quantity of the same earth which they contain, and taken in another state. It is possible that some portion of vegetable life remains in them which we are unable to appreciate or discover. A circumstance which seems to tend greatly to the support of my opinion is, that it has been every where observed that ashes resulting from the combustion of a slow fire, and which have been formed, as much as possible, away from all contact with the atmosphere, constitute a much more efficacious manure than those resulting from a fierce, quick fire.

In order to render ashes which have not been lixiviated more active, they are sometimes mixed with recently calcined or pulverized lime; and these substances, after having been carefully mixed together, are slightly moistened. By means of this process, the potash contained in the ashes is rendered caustic. A small quantity of this mixture is used as a dressing for clover; in paring and burning, also, a little lime is generally mingled with the ashes of the turf.

Although this may appear to be the proper place for entering into a consideration of the operation of paring and burning, we shall, nevertheless, defer all mention of it until we come to treat of tillage generally, to which division it certainly belongs.

Of all the lixiviated ashes that are used, the refuse ashes of bleachers and soap-boilers are generally preferred. These contain only a small quantity of potash, but are mixed with lime, and not unfrequently with gelatinous portions of the residue of the melted fat and other substances used in the manufacture of candles and soap. It not unfrequently happens that soap manufacturers mix the

sweepings of their houses and yards with the ashes; but this does not tend to improve them. The excellent effects resulting from this species of manure are now so well known, that it is eagerly bought and carried to immense distances; but not more than twenty years have elapsed since it was thrown away as rubbish.

This kind of manure is usually devoted to meadow-land. The ashes are spread over the turf; whence, in a very short time, they cause grass or the varieties of clover to appear, and replace the moss or stunted grass which previously grew there.

Nor are these ashes productive of less beneficial effects on arable land; only, like all other manures of a similar nature, care must be taken that they shall be intimately and completely blended with the soil; and to effect this, they must be only superficially buried at first, in order that the harrow may reach and distribute them. The quantity usually allowed for an acre of land is eighteen, twenty, or, at most, thirty bushels spread equally over it. There are places in which agriculturists do not scruple to pay from five to six rix-dollars (21s. 3d. to 25s. 6d.) for an amelioration of this nature; but in other districts it can be procured at a much cheaper rate.

It is not, however, productive of its most beneficial effects, unless the land to which it is applied be thoroughly impregnated with stable manure: on an impoverished soil, it seldom answers the expectations of those who make use of it. This accounts for the fact that the practice of using this substance is held in the highest estimation in those places where land is kept in pretty tolerable condition. Its effects, too, are then far more durable. Many persons assert that they are perceptible for ten or twelve years; but such is not the case, as Benekendorf justly observes, unless the land is manured afresh.

In places where there is a superabundance of wood, and where the demand for this substance is so small that the most profitable use which can be made of it is to subject it to incineration, in order to obtain potash from it, the residue resulting from this operation may be used with the greatest advantage for the amelioration of land, and the benefits thus obtained are often so great as to cover the whole of the expenses. These ashes are carried to soils which have been repeatedly plowed, or are used to accelerate the amelioration of newly-tilled forest land. Every farm possesses some portion of lixiviated ashes; and however small this portion may be, it is still worth while to preserve it. If, as is generally the case, the ashes are thrown together in a heap on the dung-hill, they are productive of little or no good, because they do not produce all the benefit of which they are susceptible, unless spread thinly and evenly over the soil. Here, on the contrary, they would be amassed together, and likely to destroy the vegetation on those spots with which they came in contact.

Not only do peat ashes differ essentially from wood ashes in containing little or no potash, but the constituent parts of ashes resulting from varieties of peat are likewise very dissimilar. Lime generally forms the chief constituent of these ashes, provided that the peat from which they are obtained does not contain too large a portion of sand. This lime exists in the form of a carbonate, or in conjunction with sulphuric, phosphoric, and acetic acids. It is usually combined with a considerable portion of oxide of iron, and sometimes, also, of sulphate of iron, when this latter substance has not been decomposed by the intensity of the fire.

The differences which are observable in the properties of peat ashes regarded as a manure, probably arise from the variations which exist in the nature of the constituent parts of peat itself. There are as yet so few well authenticated experiments on the nature of peat ashes, or carefully investigated analysis of them made with reference to their ameliorating qualities, that nothing positive can be said on the subject. It has everywhere been found that light friable ashes are productive of more beneficial effects than those which are heavy, doubtless because they contain less silica. Some persons prefer the white ashes, others the grey, and others those which are of a reddish hue: this latter color arises from the presence of oxide of iron. I have seen more harm than good resulting from the use of peat ashes of a red brown hue, which contained a great deal of iron, and also of silica, and am, therefore, inclined to believe—at any rate, until farther experience shall convince me to the contrary—that oxide of iron is not pro-

ductive of beneficial effects on vegetation. This point, certainly, is well worthy of investigation, especially in those countries where a great deal of peat is burned. This species of ashes is the more frequently used as manure, in consequence of there being no possibility of applying it to any other purpose.

But, in some parts of England and of Holland, peat is burned expressly for the purpose of making use of its ashes in the amelioration of land. Considerable extents of marshy land are devoted to the growth of peat. Kilns or furnaces, constructed of stone or clay, are built near to these places; at the bottom of which, on the grating, a layer of dry peat is laid first, which is succeeded by a layer of peat in the state of moisture in which it is taken from the marsh. The undermost layer is then set on fire, and its heat speedily dries the one above it, and causes it also to ignite; so that after the fire is once permanently kindled, it can be kept up without the necessity of adding more dry peat. The combustion is never suffered to proceed too rapidly, because it is well known that the ashes lose much of their ameliorating properties when the peat has been too rapidly consumed. The ashes are withdrawn from beneath the grating, and thus the process goes on, and with it the formation of fresh ashes; while those that have been produced are carried away.

Latterly, so great a virtue has been attributed in England to the action of ashes, that agriculturists have been advised not only to burn the stubble which is left on the ground after the corn has been reaped, but also to strew the whole of the straw over the soil, and destroy it by combustion. In support of this advice, experiments have been brought forward to prove that much greater benefits have been thus derived from the straw than it would have produced if mingled with the dung. We shall not enter into any discussion with respect to the merits or demerits of this theory, because it can only be applicable to certain peculiar circumstances and to very fertile soils. The practice of setting fire to the stubble, which for this purpose is left very long, is much followed in Hungary, in districts where the soil is very rich.

The residue of salt-works, and the sediment which settles in or attaches itself to the sides of coppers or boilers—which matters are often mixed with ashes—may be classed among the number of very active manures. Agriculturists eagerly purchase these substances, and not unfrequently at a very high price. The sediment of large coppers or boilers is, for the most part, composed of gypsum; sometimes, however, it contains a little salt. Many persons prefer it to gypsum, while others do not attribute an equal value to it.

Agriculturists have been frequently led away and deceived by wonderful accounts of various salts, which, if employed in ever so small a quantity, were to produce miraculous effects. These offsprings, however, of quackery and an excessive love of gain are, happily for us, rapidly losing ground.*

But I must not be understood to confound those artificial compositions of gypsum, oxide of iron, common salt, &c. and, among others, the valuable essays and recommendations of Lampadius Freyberg ("Leipsicher Economishe Anzeigen Michaelis," 1805. A.) with those ridiculous inventions; for these are used in suitable proportions, and, not like the miraculous salts, in quantities not exceeding a few ounces or pounds per acre.

There does not appear to be the least doubt that by using successively and appropriately warm, active, animal manures, durable and refreshing vegetable matters and ameliorations composed of mineral substances, which accelerate decomposition, that by successively bringing into action one or other of the different varieties of each of these species of manures, a greater amount of produce may be obtained than if one kind only were used. But, in order to obtain this success, attention, doubtless, must be paid to the order, proportion, and period which best agrees with the nature of the soil, the condition in which it is, and the number of crops it has borne since last ameliorated. In many countries, certain positive rules have been laid down with regard to this subject; but these rules want practical and fundamental utility. Theoretically speaking, nothing more can be said on this subject than we have already advanced, because we look in vain for positive and well authenticated experiments calculated to remove our doubts. There is a wide field open to the researches of the chemist and scientific agriculturist;

* Not so in this country. "New manures" were never so numerous as at the present time.

and it is to be hoped that the direction of a patient, scientific and accurate investigation to this subject will not fail to produce new and important discoveries, which will teach us how to apply all those substances with which we are furnished by Nature, so as best to attain the end for which they were bestowed—namely, the multiplication of living beings, and of the comforts and necessaries of life.

Since Nau Reissert and Seitz have opened the lists in the "Annals of Agriculture," ("Annalen des Ackerbau," vol. ix. p. 210,) we may venture to hope that new experiments will soon determine how far certain species of manures are suitable to certain plants, both as regards their influence on the abundance and quality of the produce. All that is at present known on this subject will be narrated when we come to speak of the cultivation of each separate kind of produce.

An agriculturist who has at his disposal those kinds of manure which are not in general use, and who knows how to employ them properly, may venture to deviate from that straight path which a person who cannot procure these substances, or does not know how to use them, must tread without swerving. By means of this variety of manures, the former may adopt a system of cultivation, a rotation, or succession of crops, better adapted to the circumstances and the demands of the passing hour, or to his own convenience, than that which he would otherwise be compelled to follow. When he can obtain street mud, or sweepings, the residue of some manufacture, or a supply of rich mould, he will be able to save the stable manure, and, perhaps, diminish the extent of land devoted to the purpose of raising fodder. Gypsum preserves to naturally rich lands the capability of producing clover for a considerable period, provided that the soil is not too deeply plowed.

But, on the other hand, those agriculturists who do not possess such extraneous means must not allow themselves to be tempted to imitate their more fortunate neighbors, or strive to emulate the brilliant success, with the causes of which they are too frequently unacquainted.

PART II....ON THE TILLAGE OF THE SOIL, OR ITS MECHANICAL AMELIORATION.

I shall devote this portion of my work to an enumeration and description of those various labors and operations by means of which the soil is rendered capable of producing the various crops which we require from it, and by which its physical condition is adapted to the attainment of the end which the agriculturist has in view.

These operations are all comprised in the two following divisions:

1. Those the effects of which are permanent, or at all events of considerable duration; such as are designated under the title of ameliorations, viz. the improving the land, the formations of hedges, ditches, and enclosures in general; also draining, digging, forming canals for the purpose of irrigation, &c.

2. Those which have relation only to the succeeding crops and to their sowings, and which must be repeated every year, or at any rate at certain short intervals. The latter are comprised under the denomination of tillage: various circumstances tend to induce us to occupy ourselves in the first place with this division, and then proceed to a consideration of the more durable improvements.

However evident the necessity of tillage may be, there are, nevertheless, various opinions with respect to the manner in which it ought to be performed, as well in general as in special cases, and with regard to the selection of the various methods or practices which should be followed. Success has favored alternately one or another of these; and hence an agriculturist who has received a merely practical education, will do well to act upon the precepts and follow the rules handed down to him by his forefathers. Such a course of proceeding certainly does not hold out the prospect of any advantages which are not likewise enjoyed by his neighbors, but at the same time it exempts him from the evils frequently entailed by speculations. Should he undertake new systems of operation without being thoroughly acquainted with their end and purpose, and with all the considerations which should induce him to follow or reject them, he will be far more likely to experience sensible losses than to attain to any real good. An enlightened and scientific agriculturist, on the other hand, whose endeavor it is to arrive at the highest degree of perfection of which his art is capable, may enter upon new modes of operation without risk, when he knows the effects which

the course of proceeding which he is adopting are calculated to produce, the results with which each operation will probably be attended, and can appreciate and understand the causes which have influenced the success of one mode, and sometimes of another.

The practice of Agriculture has in view numerous and varied objects, all of which cannot be attained in the same manner. It is, therefore, highly essential that a clear idea should be entertained of the effect which is intended that a certain course of proceedings shall produce, not only in each isolated case, but also in the combination of all these cases with one another, in order that by means of this knowledge we may be enabled to select that mode of operation which will at once attain the required aim in the best possible manner and at the smallest possible expense.

The following are, in general, the objects and effects of tillage:—

1. *The loosening and pulverization of the soil.* All kinds of land have a natural disposition to agglomerate and become too close, either in consequence of the attraction of cohesion of their particles, or of the pressure exercised on them by the atmosphere. The more argillaceous a soil is, the greater is this consistence and agglomeration. But most of the plants we cultivate are unable to penetrate so hard a soil, or to derive from it the nourishment requisite for their support. It is, therefore, necessary that the soil should be loosened by some mechanical process; and this should be done as perfectly as possible, in order that rich vegetation may be produced, and all the nutritive matters contained in the ground be placed within the reach of the roots of plants. To effect this, it is requisite that the layer of vegetable earth should be pulverized, until not a single clod or lump remains. The fibrous roots of the plants do not penetrate these clods; all they can do is to wind themselves around them, and, consequently, clods of earth scarcely yield more nourishment than stones.

The more homogeneous, loose, and pulverulent a soil is, the more equally will it be penetrated by the roots of plants growing on it, the more hair-like and fibrous roots will these plants put forth, and the more are the ramifications of these roots separated from each other; so that thus all the nutritive particles contained in the soil are brought into contact with some one of the suckers put forth by the roots of the plants.

Some authors, and especially Jethro Tull, convinced by personal experience of the wonderful effects resulting from a complete pulverization of the vegetable layer of earth, have been led to believe that the fertility of the soil was produced solely by this cause; but it has since been clearly proved that such an assertion is not correct. When a field to all appearance exhausted has been allowed to agglomerate together in clods and lumps, there is no doubt that if it were carefully pulverized it might be made to bear one or two crops of grain; but this is only because the nutritive juices and particles which it contained are thus brought within the reach of the roots of plants, and not because this operation is able to create one particle of nutrition.

A soil can never be too much loosened and pulverized; it may, however, be rendered too light and spongy; that is to say, interstices may be formed in it, and there are vacuums existing between its particles. These voids or interstices are injurious to plants. It has often been noticed that divers kinds of products suffer when they have been sown on recently plowed land which has not had time to sink down again, and, consequently, is full of interstices.

The comparative difficulty or facility with which this pulverization can be effected, depends in a great measure on the nature and composition of the soil: this is the reason that the operations by means of which it is brought about differ so much in their degrees of intensity, and why it is necessary to repeat them so much oftener on some soils than on others. Besides, the degree of pulverization bestowed on land must depend on the kind of plant which is to be sown there: barley thrives best on very loose and pulverized soils, while oats succeed equally well, if not better, on land which has not been so much loosened; this kind of grain vegetates most vigorously on those soils the particles of which agglomerate together.

Several years will elapse before a soil which has been properly pulverized will become hard, or before a crust will be formed beneath its surface. If it is composed of clay, it contracts a certain degree of adherence with itself; but this is

never so great as to prevent the roots of plants from penetrating it, therefore the loosening and pulverization of that part of the soil beneath the layer turned up by the plow is seldom repeated above once in a certain term of years.

2. *The complete mixture of the parts of which the soil is composed.* It is never more imperatively necessary to effect a thorough mixture of all the component parts of the soil, than when the layer of vegetable earth has been augmented by deep plowings, which have brought the virgin earth to the surface, or by the addition of substances calculated to improve or ameliorate it. An earthy mass composed of heterogeneous substances is positively injurious to the roots of plants: vegetation is impeded when the young fibrous roots of plants pass from one kind of earth into another. An imperfectly mixed soil, consequently, produces stunted, sickly and diseased plants: many soils have been rendered almost barren for several years, in consequence of the ameliorating earth which was carted on to them not having been properly blended with the vegetable mould; even the beneficial effects of marl are neutralized by want of attention to this essential point; in fact, the advantage which such substances are capable of producing never becomes apparent until they are thoroughly incorporated with the soil. Several kinds of manure, and especially those the fertilizing effects of which arise from their action on the humus and vegetable matters contained in the soil, likewise remain inert, if not properly divided and mixed with the vegetable mould, and are even likely to become injurious if they come in contact with the roots of plants before they are perfectly divided. Common stable manure is not altogether inefficacious, even when suffered to remain in lumps, because its soluble portions penetrate into the vegetable soil; but it is not productive of that amount of advantage which might have been derived from it, if it had been completely divided and mixed with the land by means of repeated plowings. When stable manure has not been properly divided, *the plants shoot up in tufts* where they find an abundant supply of aliment; while *those spots which contain little or no manure, either remain totally barren, or produce only a few sickly plants.* A manure of this kind, when suffered to remain in the soil in lumps, subsequently forms a species of peat; and this *inequality* in the growth of the crops *will continue for several years.*

3. *The bringing a layer of earth, taken from a considerable depth, to the surface of the soil,* in order to submit it to the influence of light and of the atmosphere. From the remotest ages of antiquity, the advantages resulting from the aeration of land have been known and recognized by all attentive observers, and various hypotheses have been advanced to account for this fact. The effect thus produced has been compared to the formation of saltpetre (nitrate of potash), and, in fact, it is somewhat similar, since saltpetre is produced by the confluence of some atmospheric substances; and the oftener a new surface, and one which had not previously been saturated, is brought into contact with the air, the greater is the quantity produced. The same substance (oxygen) acts in this case as in the formation of saltpetre. It is by its assistance that those two matters are formed, in which carbon forms the constituent part of the nutrition of plants, namely, carbonic acid and soluble extract. It is only from exposure to the air that humus acquires its fertility, and there is little doubt that light has a good deal to do with the production of this effect.

The soil appropriates to itself that portion of carbonic acid which is formed by the combination of oxygen with the carbon, and that remains in the inferior stratum of the atmosphere, and is, in a manner, buried in the interstices of the earth which is turned over. It is not improbable that even the nitrogen contained in the atmospheric air, separated from the oxygen, has something to do with the amendment of the soil, and is absorbed by clay. Although we are not yet acquainted with all the various decompositions which are effected, yet general experience teaches us that even the most tenacious clays may be rendered fertile and permeable, by having their surface frequently changed, and fresh portions submitted to the action of the atmospheric air. The amelioration thus derived from the atmosphere, and the absorption of substances adapted for the fertilization of land, may be made to replace other ameliorations for a certain period of years; but the effects produced by it are neither so complete nor so durable.—According to Du Hamel (Treatise on the Amelioration of Land, p. 64), the effects produced by this operation are so sensible that they are perceptible at first sight.

"If," says he, "half of a field is moderately plowed, and the other half repeatedly plowed, and these two portions are subsequently plowed athwart, that half which has been most frequently turned over and stirred will be much browner than the other."

4. *The absorbing, introducing into the soil, and preserving the moisture which falls from the atmosphere.* Moisture does not penetrate into argillaceous, close, or tenacious soils. When a clod of this nature remains unbroken in the soil, and becomes dry, it preserves the dryness in the centre during the whole summer.—But the more the particles of the soil are separated from one another, and the more deeply the land is turned up, the more easily does the moisture penetrate into the interstices; in fact, the deeper the plowing is, the more easily does the land absorb and retain humidity. When land has been thus prepared, the water does not flow back to the surface so soon, nor is it so speedily dried up and evaporated in dry weather, but communicated to the surface in proper proportions.—These observations will be found to be everywhere confirmed by experience; and it has invariably been noticed that land which has been deeply and carefully turned over and stirred up does not soon become hardened on the surface, neither does it suffer so much as other land from drouth. Every gardener who has dug up any portion of his land must acknowledge the truth of this observation. Soils which have been plowed in the autumn resist the drouth of spring in an almost incredible manner; in fact, they preserve a fair degree of humidity at the depth of an inch below their surface, while others are parched to a very great depth. It is not, therefore, literally true that plowing dries land; such an effect can only be produced when the plowings are deep and frequent, and always performed in dry weather. It has been observed that a slight plowing, which only moves the surface of the soil, tends rather to preserve than to dissipate the moisture; and, consequently, the insensible absorption of moisture by the soil from the air is greater than the evaporation.

The humidity which is enclosed in the interstices of the soil, and which amasses there in large quantities when the land is fallowed before winter, is doubtless attended with this disadvantage; but there is no reason to fear that it will render the soil too tenacious and compact during the whole summer. Attentive observers have remarked, on the other hand, that such soils are lighter, more friable, and divide with less difficulty, provided that we wait until they are dry: this is a natural consequence of the evaporation of that water, the elasticity of which had separated the particles of the soil by introducing itself between them.

5. *The destruction of weeds.* In treating of the method of knowing and judging lands, we have divided weeds into two classes—those which increase and multiply by means of their seeds, and those which are propagated by means of their roots alone. This distinction is very essential as regards the destruction of weeds by plowing.

Those weeds which are produced from seeds can only be destroyed by the seeds contained in the soil being successively brought to the surface, and thus enabled to germinate; for, otherwise, they might remain whole centuries in the land without losing their vitality. Many, and, indeed, by far the greater part, of the little seeds do not germinate at all, unless brought into free contact with the atmosphere—which cannot happen while they remain enclosed in clods of earth; therefore, until these clods are pulverized, the seeds contained in them are totally inert.

There is not the least chance of completely destroying the seeds contained in the soil, or even in the part brought to the surface, unless all the clods and lumps of earth are thoroughly pulverized. It is not, therefore, sufficient that each layer, however thin it may be, should be brought to the surface, and into contact with the atmospheric air; it must also be broken, divided, and reduced to powder. The plow alone cannot effect this purpose, and recourse must likewise be had to the harrow.

But in order to clear the soil of those weeds which are propagated by means of their roots, and especially couch-grass (*triticum repens*), creeping bent-grass (*agrostis stolonifera*), and various other gramineous weeds; the corn or way-thistle (*serratula arvensis*), and other varieties of thistle, docks, &c., a totally different course of proceeding must be adopted. The only means of destroying these plants is to break off the young roots and shoots, or to tear them up and

expose them to the influence of light and air. They must be brought to the surface of the soil, separated from the earth, and placed in a position in which they cannot vegetate afresh, as they certainly would if the earth detached from the clods were suffered to fall on them again. The harrow while it tears up the roots from one place plants them in another, by surrounding and covering them with loose earth, in which they soon put forth new shoots. When, therefore, it becomes necessary to destroy such roots, the ground should not be harrowed until a short time before it is to receive a fresh plowing; in order that the roots buried by the harrow shall not have time to vegetate before they are destroyed by the plow.

6. *Burying the manure.* We have already spoken of the mode of effecting an admixture of the dung with the soil. When the manure is to be buried with the first plowing, care must be taken that it shall be placed in a position where, according to its nature, it may produce the most immediate and beneficial effect on the first crop which succeeds the application; or, if the land has to be plowed several times, that the manure shall be placed so as to be *completely mixed* with the soil. Long, strawy manure requires a deep furrow which will contain it; *rotten dung*, on the contrary, ought *only to be covered by a very thin layer of earth;* therefore the plowings intended to bury it need not be very deep.

7. *Burying the seed.* Whether this operation be performed with the plow, the harrow, or any other instrument, the greatest possible attention must be bestowed on the execution of the plowing which precedes the sowing, in order that the seed sown, whatever may be its kind, shall be placed in the position best calculated to facilitate its germination, when even the finest of its roots may be able to find nourishment and shelter, and where even its stem can attain the most perfect development without hindrance.

AGRICULTURAL IMPLEMENTS.*

Having pointed out the principal object which tillage is intended to effect, we will now proceed to examine into the nature and construction of the various instruments by means of which these different operations can best be accomplished, and the end in view attained with the greatest advantage and precision.

* The implements which mankind have employed in the cultivation of the earth, and their gradual improvement, (observes Mr. J. Allan Ransome, in his excellent work on the *Implements of Agriculture*,) is a theme closely connected with the history of Agriculture.

In tracing the gradual progress of farming implements towards their present state of perfection, it will be readily understood how steadily, in all ages and countries, they have improved as Agriculture has advanced, and how stationary they have ever remained in those countries where the science of Agriculture is neglected. It would even seem that there is an intimate connection between the establishment of freedom of thought and of action, and of the progress of agricultural arts and agricultural life, of all modes of life the most conducive to health, to virtue, and to enjoyment. The cultivation of the soil necessarily requires the construction of implements for the purpose; and it is gratifying to observe the progress which has been made in them in Holland, in America, and in England, and contrast the beautiful and labor-lessening implements of Agriculture which these free countries possess, with those of the cultivators of Spain, of Portugal, and of Russia, or of the more degraded slaves and ryotts of the countries of the East, such as those of Palestine, and of the banks of the Ganges. These, it is more than probable, have remained unaltered, without any successful attempt at improvement, for two thousand years. Thus we find that the Israelites, instead of employing in their warm climate a threshing machine, or even a flail, to thresh out their corn, were accustomed to turn their oxen on to the barn floor to slowly tread out the seed. "Thou shalt not muzzle the ox when he treadeth out the corn." (Deut. xxxv. 4; 1 Cor. ix. 9; 1 Tim. v 18.) And this rude mode is still the custom in Syria, and even in Portugal; and the Moors and Arabs (says Dr. Shaw, in his "Travels in Palestine,") still continue to tread out their corn in this way.

And, in accordance with this neglect of labor-lessening implements, scarcely any expedients beyond the most primitive appear to have been adopted in the culitvation of the earth. Thus we find the prophet Isaiah declaring (xxxii. 20), "Blessed are they that sow beside still waters, that send forth thither the feet of the ox and the ass." Sir John Chardin, and others, have described an indolent practice still prevalent in the Oriental countries, which explains this expression of the prophet. It seems that in planting rice, which is a crop that only flourishes in wet, swampy grounds by the banks of rivers, that while the earth is yet covered with water, they cause it to be trodden by oxen, asses, &c., and that, after the upper portion of the ground has been thus imperfectly disturbed, they sprinkle the rice on the surface of the water.

And if the ground is thus rudely prepared to receive the seed by the action of the feet of cattle, in a manner equally imperfect is the seed covered with the earth by these untutored cultivators. The English farmer must not expect to find in these ill-farmed and unenlightened countries any instruments even remotely resembling the compact and powerful harrows of this country; instead of these, the branch of a tree, or a few logs of wood fastened coarsely together, and dragged slowly over the surface of the very thinly and partially disturbed soil by oxen, are the only means employed to cover the seed. These instruments are thus described by G. W. Johnson: "When the plow has done its utmost on the stiff soils of Bengal, they still remain cloddy, and unfit to be a seed bed. To remedy this, a still more imperfect implement than the Indian plow is employed, which is intended to produce the combined effects of the roller and the harrow. This is nothing more in form than an English ladder made of bamboo, about eighteen feet long, drawn by four bullocks and guided by two men, who, to increase its power, stand upon it as they direct, and urge on the cattle. Again and again has it to pass over the same surface, and then, as in the case of their plow, it causes a great

The instruments are divided into two classes, those which can be worked by manual labor, and those which cannot be used without the intervention of draught cattle. The former are only adapted for the cultivation of gardens, and, therefore, scarcely come within the province of this work. There are, however, no doubt, circumstances under which these instruments may be used with advantage in the tillage of fields, but such cases are of rare occurrence. Whether or not it may be advantageous to substitute the spade or hoe for the plow when a sufficiency of laborers can be obtained, is a problem which we are not called upon to solve, since in by far the greater part of Europe spade-husbandry cannot be employed to any great extent without employing more hands than can be spared from other occupations; and in those places where the population is sufficiently numerous to admit of this being done, the tillage of fields is replaced by the cultivation of gardens. We may, therefore, regard digging and plowing as the distinctive characteristics of these two kinds of cultivation.

There is not a doubt that land may be as well tilled and rendered as fertile by means of good agricultural implements worked by cattle, as it could be by manual or spade-labor, and at much less expense. The crops which succeed to a good digging are, however, often far better than those which follow a slight or careless plowing.*

The instruments that are used for the purpose of tilling the soil and preparing

expense of time and labor without any commensurate effect. The Indian ryots show their consciousness of the reason that the operation of pulverizing and leveling is beneficial, by calling it *Rasbandham*, that is, *the confining of the moisture*."—*Asiatic Res.*, vol. x. p. 4.

And, in countries somewhat more civilized, the construction of agricultural implements has hardly progressed more rapidly than in the East, for even in many parts of Europe they still use plows of the heaviest and most ill-constructed character. Their teams, too, are equally neglected; horses, cows, asses, and even goats, are harnessed together in a most wretched manner, just as was the custom, it would appear, in very primitive times in Palestine. (Deut. xxii. 10.) The German farmers still use, instead of a plow, an instrument called a "haken," which is exactly similar to one used by the Roman farmers. Their harrows have commonly only wooden teeth, and are worked with five horses in a very bungling manner. (*Johnson's Farm. Encyclopædia*, p. 559.) And still farther north, the Muscovite harrows are formed even in a ruder way, by merely fastening together the branches of the fir tree, whose projecting, partially trimmed spurs form the teeth, while the implement they use for a plow is little more than a shapeless bundle of sticks tied together with tarred rope.

As long, in fact, as men continued to till the earth as slaves, sowing a crop they were not sure of reaping, degraded in spirit, and totally uneducated, it was in vain to expect superior implements of any kind, or any efforts, however slight, towards the improvement of Agriculture. In our own Island, for instance, plows were,.during the early and dark ages of its history, rudely constructed, intolerably heavy, and of all kinds of shapes, a result which might have been reasonably anticipated; for by an old British law every plowman was required to make his own plow. The harrows and other agricultural implements were equally ill-shaped. Drills were utterly unknown until about the sixteenth century. And when, about the year 1730, the celebrated Jethro Tull endeavored to banish the flail from the barn, his neighbors loaded him with execrations. The tradition of the neighborhood of Prosperous farm, near Hungerford, which Tull cultivated, still is, that he was "wicked enough to construct a machine, which, by working a set of sticks, beat out the corn without manual labor." This is the earliest traditionary notice of a threshing machine with which I am acquainted. Jethro Tull, indeed, must ever be regarded as one of the earliest improvers of English agricultural implements; his plows, his horse-hoes, and his ingenious attempts to construct a drill machine, evince a spirit of inquiry, and an advance in agricultural mechanics, which betoken at once his ability and his enthusiasm. He was far indeed before the general agricultural knowledge of his age; and if he did now and then suffer his enthusiasm to carry him too far in his conclusions, yet the very effort to improve in hands like his was sure to be attended with a measure of good success, for his exertions not only produced immediate good fruits, but they widely diffused a very general and well-founded suspicion that the implements of that age were not quite so perfect as they might be made. This led to considerable improvements, and prepared the way for still more important efforts by the next generation of implement makers.

* Spade husbandry has certainly been extending itself in England within the last few years. The late Dr. Yelloly described its introduction into the parish of Wymondam, in Norfolk, where it seems many acres were dug (land after a white crop) at 2d. and 2½d. per rod. Of late, the fork has in many places superseded the spade, since it lessens labor, and is better adapted to penetrate the hard substances on which many shallow soils rest. The spade has long been employed in the husbandry of Spain, France, and other continental States. Rev. W. Rham observes, (*Jour. Roy. Ag. Soc.*, vol. ii. p. 43,) "The husbandry of the whole of the north-eastern part of East Flanders, where the soil is a good sandy loam, may be considered as a mixed cultivation, partly by the plow and partly by the spade. Without the spade, it would be impossible to give that finish to the land, after it is sown, which makes it appear so like a garden, and which is the chief cause of the more certain vegetation of the seed. There is a great saving of seed by this practice, as may be seen by comparing the quantity usually sown in Flanders with that which is required in other countries, where the spade is more sparingly used. In large farms in England, the spade is only used to dig out water-furrows, and to turn heaps of earth, which are made into composts with different kinds of manure. But in Flanders, where the land is usually laid in stitches of about six or seven feet wide, the intervals are always dug out with the spade, and the earth spread evenly (*sifted*, as they call it) over the seed which has been harrowed in.

The trenches are so arranged, that every year a fresh portion of the ground is dug out, and in six years the whole land will have been dug to the depth of at least one foot. In the next course, the trench is dug a few inches deeper. which brings up a little of the subsoil; and, after four or five such courses of trenching, the whole soil comes to be of an uniform quality to the depth of eighteen or twenty inches; a most important circumstance to the growth of flax, potatoes, and carrots, all of which are very profitable crops to the farmer, and the two last indispensable to the maintenance of the laborers and the cattle. In the Waes country, they proceed differently, for they have a soil which, by repeated trenchings, has long been uniform

it for the reception of the seeds and plants, and which are worked by cattle, are very numerous, but they may all be comprised under the three following classes:—

(*a*) The *plow*. The intention of this implement is not only to divide the earth, to loosen and throw it a little on one side, but also to turn it over from a given depth, so that the lower part of the furrow separated by the plow shall be brought to the top, and a new surface exposed to the atmosphere. This effect is produced by that part of the instrument which is termed the mould-board, and which is usually placed at the right-hand side of the plow.

(*b*) The *grubber*. This instrument loosens, stirs, and divides the soil, and cleanses it from roots and weeds, but does not turn it over; because it has not a mould-board.

(*c*) *Hoes* and *cultivators*. Under this denomination I comprise all kinds of horse-rakes, hoes, extirpators, scarifiers, drills, and sowing machines, &c. which only loosen the surface of the soil, and which are used for the purpose of preparing and effecting the sowings, or cultivating the crops during their vegetation.

The plow,* in the strictest sense of the word. This implement ought to separate or detach from the ground successive sods or slices of earth parallel with the surface, but cutting them vertically by means of the coulter, and horizontally

in quality to the required depth. There they regularly trench one-sixth part of the land every year, and plant it with potatoes, or sow carrots in it.

In a recent communication, Mr. J. Beadel, a very experienced farmer and land-agent of Witham, in Essex (who has used a fork of an improved construction to a considerable extent,) observes, when comparing the use of the fork with that of the spade:—

1. A man can dig a greater quantity of land in a given time with the fork, than he can with a spade—my experience proves one-sixth; and it strikes me it must be so, because the chisel-pointed ends of a three pronged fork, can be more easily pushed into a hard subsoil, than the continuous end of a spade.

2. It does not bring up so much of the subsoil as the spade, but mixes the earth more, a great portion slipping through between the prongs.

3. The bottom is left more uneven and broken by the fork than by the spade, which I consider an advantage. One great objection to the plow is, I think, the smooth glazed surface which it leaves below, and which in many cases, I fancy, presents too great a resistance to the delicate fibres of the plant. This is *heterodox*, but if true, the plow will be altered *one day*. And if Mr. John Morton be correct, that in most instances the present surface soil is nothing more than a portion of the subsoil improved by cultivation, it must be right to increase the quantum of corn-growing earth by subjecting more subsoil to the same operation. In digging, I sometimes use the fork in the furrow, and then plow on to the dug land, and so keep the top soil on the surface, without bringing the hungry subsoil into play, till after it has been subjected to the operations of a regular rotation.

* I must beg my readers to regard the minute directions given, rather as intended to assist in the choice and use of plows, than in the fabrication of them. It is exceedingly necessary that an agriculturist should not only perfectly understand the effects which will be produced by certain modifications in the form of the plow, but likewise to be able to remedy those inconveniences which are frequently met with while using this implement; in fact, he ought to know how to employ it so as to produce the greatest advantage. The author, doubtless, had this end in view in the instructions which he gives. But agriculturists are very much mistaken when they imagine that they can invent new plows, and have them constructed on their own premises, and under their own eyes. These kinds of instruments are not easily imitated: their mechanism is difficult, and requires skill and attention: those persons, therefore, who chose to invent and fabricate them themselves, instead of procuring them from the proper manufactories, lose a great deal of time, and expend three or four times the sum which it would have cost them to procure the plow even from a considerable distance. The usual effect of such attempts is to disgust the essayists with all improvements, and to cause those who relate actual facts to be accused of forming speculative and groundless opinions.

I have, myself, experienced the annoyances from which I am endeavoring to preserve others. I endeavored, for a long time, to construct one of Small's plows, according to the directions which I found in several English authors, and flattered myself that I had attained some degree of success, but it proved to be ephemeral. Attributing those imperfections which resulted from my own inexperience, to the nature of the thing itself. I uttered a general protest against all plows having an immovable and concave mould-board, until reflection convinced me of the utility of a principle which, in spite of my failure and mistakes, appeared to be evidently good. At this period, Schwertz's work on the Agriculture of Belgium was obligingly forwarded to me by the celebrated de Fellenberg; I there found a description of the Ostmale plow, which threw a new light upon the subject. But, this time, I determined not to risk the success of my experiment by entrusting the fabrication of this instrument to the workmen in my vicinity; I therefore ordered it direct from Ostmale, and obtained very satisfactory results from the first trials which I made of it. But I continued to experience innumerable difficulties when I endeavored to get this instrument imitated by the workmen in my neighborhood, and, at length, was once more obliged to send for a plow from Ostmale, which, notwithstanding the expenses of carriage, was actually cheaper than those made in the neighborhood, besides being very superior in quality. From that time the Ostmale plow has risen, every day, in my estimation, and in that of several persons in the vicinity; and even my laborers, now they have learned how to guide and make use of it, prefer it to all others. I hope that I shall not be considered as trespassing on the patience of my readers, if I say a few words relative to the disadvantages attending experiments with regard to the action of this instrument, which are made without proper precaution and preparation, and in which the plow has been hastily constructed by unskilful hands. After the success which I obtained from the use of the Ostmale plow, I wrote to Fellenberg on the subject. Some time afterwards, when the period fixed for the fête at Hofwyl was approaching, this celebrated agriculturist wrote me that he had made known this plow to the public, and, consequently, that he hoped I would procure him one against the fête. I surmounted many difficulties in order to fulfil his wishes, and the work was hurried on, perhaps with too much precipitation. The plow was just finished in time to reach Hofwyl on the day of the meeting of agriculturists there; it appeared a *fac simile*, but there was no opportunity of trying it before hand, and, when put in action in the presence of those assembled, the results obtained were any thing but satisfactory, on account of some inaccuracy in the smith's work, arising from want of skill. Hence, the numerous agricul-

detaching them by means of the share, raising them in general from the left and turning them quite over by means of the mould-board, so that they shall be brought as much as possible within the reach of the harrow, which should then be used to break or powder them completely. A well-formed plow is that which will perform these operations with the least resistance, in the most perfect manner, with the least risk from strain or shock, and which tries the strength of the cattle as little as possible; neither should the guidance of it require any great degree of skill, or give the plowman too much trouble.

The other qualities which constitute a good plow are as follows:—

1. It should be as simple in its construction as the end which it is destined to attain will admit; and consequently should have no useless or too complicated portions.

2. It should not be very expensive. If, indeed, a plow which cost three times as much as another will last four times as long, it will of course be cheaper.

3. It should be durable and not liable to injury, shock, or strain; not only in order that it may not cost too much, but also because it should not require repairing too often, and thus occasion an interruption of the operations and the loss of considerable time.

4. It should be capable of being easily guided and regulated, in order that the soil may be plowed more or less deeply at will, and the furrows turned up of that size and form which is deemed best. This disposition of things should be wholly independent of the plowman, both because it is not always possible to confide in him, and because the cattle have to work harder when the laborer is striving against the natural tendency of the plow.

It is likewise necessary that it should effect all those purposes pointed out in the last section, that it should cut through the earth which it has to separate, and turn it over in an equal and uniform manner; and that it should turn over the furrow slice at an angle of 140 degrees, that being an inclination which is most favorable to the action of the harrow, and consequently facilitates the pulverization of the soil.

Although the plow is one of the most necessary of all the implements employed by husbandmen, there is, perhaps, no one to which so little attention has been paid, or which has been less improved; and those alterations which have been made in its construction are, in general, far from being improvements, since most of the plows of the present day are, in point of fact, inferior to those used by the ancients; and even those in use among some of the less civilized nations are preferable. Our carriages are far superior, in point of style and convenience, to the triumphal cars of the emperors, at least if we may judge from the representations handed down to us; but our plows are not as perfect as those used by the ancient Romans. Some persons have hence inferred that the form of their plow was not susceptible of improvement, and argue that if this instrument had been capable of being constructed on any fixed principle, it must have been discovered during the long use which has been made of it. But, if we come to consider the kind of persons who have, until very lately, had to do with plows, and how seldom these instruments have been in the hands of men endowed with any great degree of reflection, science, observation, or mechanical knowledge, we shall cease to wonder at the little progress toward improvement that has been made; the fact is, that the plow has kept pace with the intellect of the men who have had to do with it.

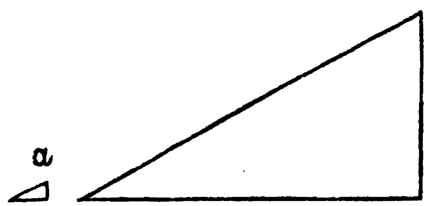
Since this point has been taken into consideration and the attention of scientific men directed to it, it has no longer been denied that the amount of labor requisite to work a plow, and the rapidity or slowness with which the operation of plowing can be performed, depends in a great measure on the structure of the instrument; and it is also allowed that this structure contributes materially towards the success of the crops and the increase of the products. Although some modern authors appear to discredit these facts, or at any rate not to believe that the expenses attendant on the introduction of new plows can be sufficiently compensated by the benefits resulting from their use; and, although some agri-

turists who were assembled at Hofwyl were led to believe that the Belgium plow did not possess all the good qualities attributed to it, and this opinion was rapidly diffused through Switzerland. Even up to the present day, the unfounded prejudice thus excited continues to exist, notwithstanding the invariable success which has attended the action of this instrument when used in its original form, and not spoiled by bungling workmen. [French Trans.

culturists assure us that they can obtain very fine crops without having recourse to any change, this only tends to prove that they cannot form an idea of the saving of time and labor resulting from the use of a good plow. The general improvement of Agriculture certainly does not depend solely on the beneficial alterations which can be made in the structure of the plow and other agricultural instruments; nevertheless, this science will never attain to all the perfection of which it is susceptible until proper attention is paid to this important point. It is on this account that a judicious and scientific agriculturist cannot do without an intimate acquaintance with, and a clear idea of, the functions and mechanism of this implement.

The essential and active parts of a plow, those which are generally called the body, are composed of the following pieces:—

(*a*.) The *coulter*. The use of this part is to cut the sod from the firm ground previous to its being raised and turned over, and to open a passage for that part of the plow which is in a direct line with it; it ought to keep the plow even, and to prevent it from turning toward the right. The coulter ought to be inclined in an oblique direction, in order to give the plow a leaning in the same direction to which it points. If we picture to ourselves the body of a plow as resembling a half angle, or a rectangular triangle, the coulter will in a manner form the point of the angle; it will prolong the side which falls perpendicularly on the base of the triangle, as in the following diagram, where *a* designates the point of the coulter.



This point determines the direction of the plow, and the manner in which it moves; and in proportion as this side of the instrument is longer, the direction will be straighter, and the action firmer.

As the extremity of the blade of the coulter forms the extreme point of the triangle or oblique surface, in order to render the plow perfect, this portion of it should never be suffered to deviate from that obliquity: we find all good plows constructed in this manner. The blade of the coulter is sharp at the edge, but gradually thickens toward the back, which is sometimes nearly or quite an inch thick. This increase of strength does not exist on the side which meets the undivided land, but on the opposite one; and, consequently, the segment of the coulter ought likewise to be in the form of a rectangular triangle. By this means the left side of the coulter will be in a direct line with the left side of the body of the plow.

In order that the coulter may open a path for the body of the plow, it is placed a little in advance of it; the point of this instrument is usually about as far before that of the share as is equal to its width. The inferior part of the sod or furrow slice separated by it from the land, is then more easily cut by the wing of the share, raised by the share itself, and thrown to the right of the plow by the mould-board. Thus, the plow is better engaged in the soil, and its course is more even.

If the coulter is not thus constructed and cannot be placed in this position, attempts are made to attain the same end by introducing the hilt into the beam in an oblique direction, so that the sharp side shall be turned outward, and a little to the left; while its back, on the contrary, shall be on the right side, and face the land already plowed. But it is evident that this arrangement must tend to increase the friction and render it greater than it would be if the coulter were in the position above described. It is equally necessary that the hole destined to receive the hilt of the coulter should be larger than the hilt itself, in order to leave room for the introduction of those wedges which must be inserted to give

to the blade the proper direction. It is by no means an easy matter to place this blade properly, or to arrange the wedges as they should be; this operation requires a great deal of care and skill, gives much trouble, and recurs very frequently, and by such means the work is frequently interrupted.

It is usually necessary to slant the wedges in order to give the blade of the coulter a sufficient inclination to the left; for the hole destined for the reception of the hilt being in the middle of the beam, a coulter placed in it in a direct line would incline too much to the right, and would not be before the point of the share, especially as the body of the plow, as we shall presently see, is not exactly in a line with the beam, but deviates a little to the left. By means of wedges, the proper direction may be given to the coulter; but then it is not perpendicular, the superior portion of the hilt inclines to the right, while the sharp point is turned towards the left. It does not, therefore, cut through the soil perpendicularly, but in a sloping direction; and does not open so free a passage for the body of the plow as it ought to do. In a superficial plowing of only three or four inches in depth, the increase of friction which will result certainly is not of any great importance; but it becomes more sensible when the land has to be plowed to the depth of six inches; on this account, therefore, those plows which are intended to turn up the soil to any considerable depth, have the coulter bent below the hilt, as is the case in Small's improved plow. By means of this bend, the coulter, properly so called, (its blade,) receives an inclination as much to the left as is requisite, although the hilt is placed in a perpendicular position. For deep plowing, in which the plow has to overcome great resistance, the firmness and solidity of the coulter may be greatly increased by means of a piece affixed to it with a screw, as is the case in Small's improved plows. By curving the coulter in the manner above stated, one great inconvenience is avoided; the man who guides the plow is not obliged to keep it constantly inclined towards the side on which the soil is untouched in order to keep it sufficiently engaged in the land.—This arrangement enables the plowman to cause the coulter, however slantingly it may be placed, to cut perpendicularly; but a still greater evil than the one just mentioned is thus produced, namely this—the share ceases to be in an horizontal position, and the furrows cut by it, instead of being even, are much thicker on the side next to the unplowed land, than they are on the opposite side, and, consequently, the plowing is very irregular.

Coulters are constructed under various forms; sometimes they are perfectly straight, at others curved like a sickle, and at others inclined in the opposite direction, having a bulge in the centre. These various forms are supposed to facilitate the entrance of this instrument into the soil: but as a curved line is longer than a straight one, it appears to me that they rather tend to increase the resistance, and that a straight coulter is by far the most preferable. The facility which a curved form is intended to give to the action of the coulter is attained quite as well when this instrument is inclined and its point projected forwards; for it is well known that a coulter always cuts best when it acts in a sloping direction, although in a line with the motion given to it. Where such is the case, the coulter cuts outwards, and is thus more easily enabled to break through the adherence of the integral portions of the soil; it then raises up the sod or furrow-slice, facilitates the entrance of the share which follows it, and tears up those roots which are too large for it to cut through: its inclined blade tends to force them upwards, so that they must either break or be torn from the soil; whereas, a coulter placed perpendicularly would push those roots which it could not cut through, onwards to the firm ground, where they would impede the motion of the plow. This instrument also raises those stones which it would be impossible to throw on one side or push forward. Lastly, an oblique direction of the coulter has the advantage of giving the plow a slight tendency to enter more deeply into the soil without increasing the friction too much. The pressure of the soil on the coulter, by steadying the anterior portion of the plow in the earth, compensates for the power exercised by the draught, which rather tends to raise this instrument. The coulter of a plow used on land which has not been freed from stones, should deviate more from the perpendicular than would be requisite in any other case; in fact, it may receive an inclination of thirty degrees from the direct line of the perpendicular.

As the coulter not unfrequently has to encounter considerable obstacles and

resistance, its strength should be proportionate to the force which it has to overcome; and as the whole of this strength cannot be given in thickness, the breadth must also be augmented. Three inches will in general be sufficient; but where the soil gives considerable opposition to the action of the plow, this breadth may be increased.

The coulter ought to be laid with steel, and as it undergoes a very great degree of friction, the steeling must often be renewed. If the same coulter is almost always used, this steel will seldom last more than a year; and in stony soils not more than six months. As the position of the coulter has considerable influence on the direction of the plow, particular attention should be paid to this point, especially if the coulter is not a very good one, and can only be kept in proper position by means of wedges. The overseer, or inspector of farm works, will, therefore, do well to examine all the plows every day, and especially this part of them, and see that every thing is in its proper place; the best way to effect this surveillance thoroughly will be to have the plows turned over; the time thus spent could not be better employed.

There are districts in which this important part of the plow is altogether done away with, and where it is replaced by that part of the share which terminates it on the left side, and which is on the same plane with the left side of the body of the plow. But it is only where the land is light, free from stones, and homogeneous, or where superficial plowings alone are requisite, that it is possible to do without the coulter. On soils of an opposite nature, which require to be deeply plowed, a plow without a coulter will perform its work very imperfectly, and will increase the labor of the draught cattle as well as that of the plowman.

The second essential part of a plow is the *share*, which separates the furrow-slice horizontally. In all well constructed plows the share ought to begin to raise the sod and to conduct it towards the mould-board on an oblique but uninterrupted surface. The share is composed of two parts—that which cuts, and which is generally called the *wing*, and that by means of which it is affixed to the body of the plow; the latter is termed the *socket*. The form of the first is greatly varied; in general, however, it is shaped like a rectangular triangle. On the side next to the unturned earth, it is in a line with the coulter and the body of the plow, and is not sharp: it is highly necessary that this direction of the left side should be carefully attended to, or otherwise the plow will not move steadily. The other side of the wing, that which is sloping, is usually laid with steel, and sharpened; it extends from the left side of the plow, and forms an angle of about forty degrees. Occasionally it receives a yet sharper angle of about thirty-five degrees, in order that it may penetrate more easily into argillaceous and tenacious soils; but it is evident that in this case the coulter must be proportionally lengthened if we would have the bases of this rectangular triangle remain the same. Sometimes this triangle is composed of one single piece of iron, and is perfectly hollow; at others, it is hollow in the middle, and surrounded by three sides. The first of these two methods is evidently preferable, because the furrow-slice separated by the blade of the share may then be gradually raised with much less friction, and passed to the oblique surface which conducts it to the mould-board.

The hinder part of the wing ought to be proportionate to the furrow-slice which it is intended to separate from the soil; that is to say, the breadth of the wing at the base ought to be nearly equal to the width of the furrow; or, in other words, the angle at the right of the share, and which forms the posterior extremity of its blade, ought to be as distant from the left side of the body of the plow as the lower part of the mould-board which rests against the slice turned over. I say nearly, because when the breadth of the furrow is nine inches, the wing may measure one less; the mould-board then turns the slice better on its own axis, because a small portion of it still remains uncut, and in contact with the soil. But this difference must not exceed an inch; if it does, the friction is increased, and the plow moves with less ease on account of the mould-board then having to overcome much greater resistance in raising the slice.

According to an essay on dynamics, the moving power requisite to put in motion a plow, the share of which was five inches wide, diminished fifty pounds, when a share measuring seven inches in width was substituted for the one just

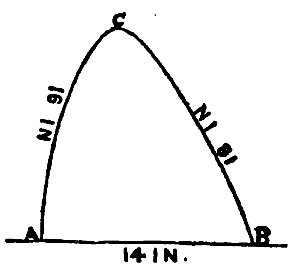
mentioned. Nevertheless, my plows are manufactured, the shares of which are too narrow even when first made, and this is an evil which is daily increased by use and wear.

The second part of the share is the *socket*, by means of which it is attached to the plow: this portion is made and fixed in various ways. The practice of fastening on the share with nails is a very bad one, and can only be used where the land is light and soft, and where it is rarely necessary to sharpen or steel the share. It is sometimes affixed to the plow by means of cramp-irons or hinges: those of our plows which are best made are merely united by means of grooves; but then, in order that the share may be sufficiently firm, the wood and iron must be carefully worked.

A well-formed share ought, as I have already stated, not only to separate the slice from the soil, but also to raise it, and to form with the mould-board an even surface, which beginning at the point of the share, gradually rises obliquely at the side. The wing of the share is itself convex, and rises as it approaches the left side. The socket must not interrupt this elevation, but rather continue it, by serving to unite the share with the mould-board, so that no inequality shall break the uniformity which ought to exist from the point of the share to the posterior part of the mould-board. This is the great and distinguishing merit of Baily's and Small's plows, and contributes materially to decrease the amount of friction. In common plows there is generally an inequality at this point, which causes the slice to be depressed before it is again raised by the mould-board.

I have met with farmers who were fully sensible of the inconvenience of this construction, and who had endeavored to obviate it by affixing a piece of iron to the neck and to the ear, which was made to rest on the hinder part of the share. They assured me that their plows were considerably improved by this means.

With respect to the form of our shares, I must refer my readers to the description of them which I have already given in my work entitled "Beschreibung der nutz barsten neuen Ackergeruethe," heft i. tafl iv. fig. 1, 2, and 3. As the socket of the share ought to be very carefully united to the body of the plow, and especially to the mould-board, many smiths find it an exceedingly difficult matter to execute this work; but this difficulty would be got rid of if they procured a model or mould of iron, around which the share may be cast in a uniform manner. They can then cast the iron of the shares, giving to them the following form and thickness:



At A the plate is 1-2 an inch thick.
" B " 2-5 "
" C " 1-4 "

When this plate has been curved on the model, it fits the body of the plow very well, and carries the furrow slice on to the mould-board with the least possible degree of friction.

This socket is applied to the neck or sheath of the plow, which is lengthened about a foot for the purpose of receiving it; it is, of course, understood that the form of this part must be made perfectly similar to that of the share. See my work above mentioned, heft i. tafl v. fig. 15 and 16.

The neck or forepart of the plow serves to unite together the different pieces at their lower extremity; it slides along at the bottom of the furrow, supporting itself against the unturned earth. In front the neck or sheath is introduced into a mortice, and at the back the left handle is united to it in a similar manner.—

The socket ought to have two sides, both perfectly connected together, the under one and the left-hand one which unite in forming a right angle.

In general, and in all good plows, the socket is protected with bands of iron as well on the lower portion as on that which rubs against the unturned earth; by this means the friction is considerably diminished, and the wood preserved from being worn away so soon as it must inevitably have been without this precaution. The same may be observed with regard to plows, the whole sockets of which are formed of forged or cast iron; these are principally intended for the purpose of breaking up meadow land; many of them are in use in the low country and in the marshes in the neighborhood of the Oder.

The length of the share determines that of the body of the plow. The question has been much disputed, whether or not, the breadth being equal, that share, the triangle of which is long, will not be superior to that in which the triangle is short, and, consequently, to that in which the angle is less acute. Those who argue in support of the former opinion allege, in defence of it, that the more acute the angle, the more easily does it enter the ground; or, to speak scientifically, the less sensible the obliquity of a surface is, the greater will be the facility with which a body can be raised on it. But here, as in most cases, that which is gained in power is lost in speed; and thus the results are rendered equal. The longer the body of a plow is, the greater will be the friction, and, consequently, the more laborious will its progress be; therefore it would be expedient to make the bodies of plows very short, if it were not that their progressive motion would be rendered less straight and regular, and if, when longer, they had not more firmness, both on the left side, which rests against the unturned earth, and on the lower part. Small's plows have short bodies, while Baily's have long ones; the latter, therefore, proceed more evenly and steadily, and can be confided to unskillful hands with greater safety.

The *mould-board* is that part of the plow which characterizes it, and serves to distinguish it from all other agricultural implements. This part ought to raise the slice which has been separated by the coulter and share, to turn it over and throw it into the furrow which was previously made. Here, then, is the greatest degree of resistance; and the ease with which it may be overcome depends upon the construction of this part of the plow. The mould-board is usually made of a thin board nailed to the right side of the head of the plow, near to the share, and the hinder part of which is maintained in its proper place, and fixed to the handle and head of the plow, by means of one or two rests. The oblique and advanced surface of this board enables it to throw the furrow-slice to the right of it, but it does not turn it completely over; for, unless this slice is tolerably firm and consistent, it will still adhere partially to the soil. In order that this may be properly accomplished, the length of the mould-board at its hinder extremity ought to be half the size of the slice raised by the plow. It is also requisite either that the mould-board should form a more obtuse angle with the left side of the plow, or that it should be very long. In either of these cases, the weight of the earth and the friction will render the progress of the plow difficult, because the whole weight of the earth rests upon the mould-board until it has passed its extremity. The quantity of earth which rests against the mould-board, and the friction produced by it, are the very causes which retard the progress of the plow.

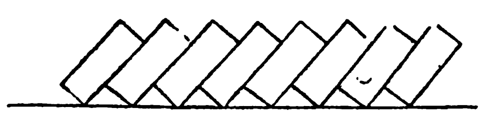
But, if the mould-board were so constructed as to enable it to free itself from this load of earth sooner, the plow would be considerably lightened. This constitutes the great advantage which curved mould-boards have over others, especially when, as I have before mentioned, they unite with the share in forming an even and uninterrupted surface. By means of this curvature the slice, in passing over the share and on to the mould-board, is turned on its own axis; so that when the revolution is half performed, it hardly touches the plow, but is impelled toward the opposite side by its own weight, and only requires a very slight touch of the posterior point of the ear to turn it over as thoroughly as is necessary.

There are still various conflicting opinions with respect to the form which it is desirable should be given to a mould-board, as well as with regard to that which is best calculated to turn over the slice in the easiest and most complete manner. In the "Museum of Natural History," No. 4, p. 322, there is a very circumstantial mathematical calculation given by President Jefferson, of the United States,

which almost exactly answers to the mould-board of Small's plows. Baily has written a paper in some other work, in which he endeavors to prove that his plow is the best; but the opinions of husbandmen are still divided between the respective merits of the two. The latter raises the slice almost insensibly, and, causing it to perform two-fifths of a circle, turns it over on its axis; Baily's plow produces a similar effect, but in a less perfect manner. Small's instruments are best adapted for plowings which extend to more than eight inches in depth; while those of Baily do the work quite as well when merely superficial plowings are requisite; and as the latter do not need so much care and attention, and it is easier to remedy error or accidents in them than in Small's plows, they are, perhaps, on the whole, preferable, especially as they are more easily guided. The differences, however, which exist in the various forms, can only be explained by reference to the plows themselves. The mould-board of Small's plow is deeper; it raises the earth higher before throwing it on one side, and it also turns it over more quickly. From being higher and shorter it sustains less friction; the difference, however, with respect to this point is only observable in deep plowings. These two plows are equally capable of gradually and obliquely raising the slice, and of conducting it on an even surface from the point of the share to the mould-board, which turns it and throws it on one side. The mould-boards of both of them get rid of the earth a great deal sooner than flat ones do. For common use, Baily's plow may be regarded as the best that can possibly be had; although the plowings performed with Small's plow are far more perfectly and beautifully executed when this instrument is well made.

Curved mould-boards are also frequently made of wood; but when this is the case, the blocks must be chosen of sufficient thickness to allow their receiving the proper form, and they must likewise be covered with plates of iron, otherwise they will soon wear away and become uneven and rough. Cast iron mould-boards are much cheaper, and, provided that the iron is not too brittle, are also more durable; besides, iron has another great advantage over wood, it causes less friction, and when polished retains less earth on its surface.

Most of those mould-boards which are not curved, turn the slice over in a very imperfect manner; only a portion of the earth raised by the share is thrown above that which previously formed the surface, unless indeed the earth consist of a continuous strip of turf adhering to itself. In order to produce a proper reversion of the soil, the distance which separates the body of the plow from the hinder part of the mould-board must be much greater; the mould-board must push the earth much farther than would otherwise be necessary, and the plow must trace a wide furrow even when the slice is narrow. The furrow in this case is sometimes half as large again as the slice. In order to throw this slice to such a distance, a greater degree of power will be requisite; because the earth rests much longer on the mould-board. Those plows, on the other hand, which have a curved mould-board, do not, properly speaking, throw the slice on one side, they merely turn it on its right shoulder. Many persons believe that flat, uncurved mould-boards turn the slice over better, because the surface of a soil which has been plowed with an instrument having one of these is always more even and horizontal. It is most true that the slice can be turned over much better when the furrow which is to receive it is considerably wider than the slice itself. Our plows turn the soil over, so that one slice rests upon another in the manner here represented.



The above form is exactly the inclination at which the spaces which are left open between each of the slices are most likely to effect the amelioration of the soil in the best and most perfect manner; by this means the air is, in a manner, enclosed in the soil and brought into contact with the inferior and under portion of it. These voids also serve to retain the water deposited by rain, &c.; and when this moisture is evaporated by heat, it tends greatly to improve the land, and the soil gradually settles down and fills up all the interstices. This surface

contains as many prisms as there are lines or streaks, and has many more points of contact with the atmosphere than a horizontal surface could possibly have; the harrow also acts more efficiently on it than on an even surface, not only pulverizing the soil completely, but also tearing up all the roots which it contains. Therefore, in all soils which require to be divided and loosened, this inclination of the slices is attended with manifest advantage; and it is only on light soils that it can by any possibility prove prejudicial. Agriculturists, whose land is of a light and friable nature, need not trouble themselves about the form of their plows; they may continue to employ those generally used in their vicinity, however imperfect they may be. Nor would our plows be productive of any bad effects, because light sandy soils not possessing any consistence will soon sink down and fill up those interstices which would otherwise remain empty.

Lastly, there are convex mould-boards made of wood or iron; these are chiefly met with in the neighborhood of the Rhine. Plows of this kind turn up the soil quickly, and progress without difficulty; but they do not turn the slice over well unless their mould-boards are made very long, which would tend greatly to increase the friction.

The piece by means of which the lower part of the plow is united to the *beam*, and which forms the anterior portion of the body of the plow, is termed the "neck" or "throat;" it is usually made of wood; and it is only in Small's plows that it is formed of iron. In all improved plows this piece is not perpendicular at the lower part of the instrument, but is inclined, so that the highest part of it at the back forms an angle of from 80 to 85 degrees. By means of this inclination that part of it which immediately follows the coulter is better able to overcome the resistance which it encounters, and is not so soon worn by friction. When the mould-board does not preserve it from wearing, recourse is had to another means of rendering it sharp; a strip of iron is then affixed to it, or that piece of iron which terminates the plow on the left hand side is lengthened;* this is the case in Small's plows. Some plows are to be met with in which the coulter rests immediately on the throat, and forms the extremity of it,† but they are deprived of the advantage resulting from this prolongation of the left side, which cannot take place without increasing the friction. However undeniably advantageous this inclination of the throat may be, many plows are constructed in which it is made to turn in quite an opposite direction. A very slight examination will, however, enable us to perceive that such an arrangement is much less advantageous, and that it renders this portion of the plow much less durable.

The *beam* is that portion by means of which the progressive motion that causes it to move through the earth is communicated to the body of the plow, and which regulates the line of draught which it is impossible to attach to the body itself.

The beam is usually affixed to the fore part of the body of the plow by means of the neck or throat, and to the hind part by means of the left handle. The union of these parts ought to be effected, so that when the draught power is attached to the proper place, the plow shall move horizontally through the earth at the same depth to which it was first introduced.

If the beam is raised too high in front, or if the neck is too long, the share is apt to penetrate too deeply into the soil; it is then said that the plow moves on its point; on the other hand, if the beam is too low and the neck too short, the share has then too great a tendency to rise out of the soil. The plow ought to move horizontally forward, or at any rate, parallel with the surface of the land, and at the same depth at which it was first placed, so that the lower part of the share and the under side of the heel of the plow shall be at equal distances from the surface. This horizontal motion is communicated to wheel plows by means of a lever, or by elongating or shortening the beam. In those which are without wheels, or in other words, in swing plows, the same effect is produced by elevating or depressing the line of draught which is affixed to the bridle at the end of the beam; but the elevation of the beam then acts inversely on the share, to which it communicates a tendency to penetrate deeper into the earth. When this is the case, the share no longer proceeds horizontally, it tears rather than cuts the soil, and the labor of the draught cattle is rendered exceedingly fatiguing. It is on this account that in wheel plows the throat is not firmly morticed into

* Beschneibung der Ackergeräthe. Heft. i. Tafl 2, fig. ii. † Ibid. Heft. i. Tafl 6, fig. ii. A.

the beam, but merely affixed to it by means of a wedge, and that some little play is allowed in the mortice, which serves to unite the beam with the handles, in order that the beam may be raised or lowered at pleasure by means of a wedge. But where this is the case, the laborers are too apt to alter the position of the wedges in order to be more certain that the share will not rise out of the ground. Notwithstanding this, the plow cannot penetrate to any very great depth, being prevented by the beam, which is itself restrained by the axis of the fore wheels on which it rests. The beam, in this case, exercises a very great degree of pressure on the axis, and thereby increases still farther the obstacles which the draught cattle have to overcome. This may be carried to such an extent, as, on tenacious soils, to cause the beam to snap at that place to which the bridle is affixed. In wheel plows this defective position of the beam is not so sensibly felt, and does not matter so much, but in swing plows the laborer can with difficulty contend against the inconveniences occasioned by it.

The length of the beam varies both in wheel and in swing plows. The longer it is, that is to say, the more distant the point of *traction* is from the body of the plow, the more steady will the motion of this instrument be, because then the slightest deviation of the share will be sensibly felt at the extremity of the beam: but this increase of length tends materially to diminish the strength of the beam; and, consequently, it must be made thicker in proportion as it is elongated.

Small's plows have shorter beams than Baily's, and this is one reason that they are more apt to deviate from the straight line. The beams of most wheel plows are usually made longer than is necessary, so much so that they project far beyond the axis. The point of the beam which rests on this axis may be drawn nearer to the body of the plow, or placed at a greater distance from it as circumstances seem to render necessary; in the former case, the point of the share will be raised, and in the latter, depressed. In order to effect these modifications, several holes are made in the beam, to any one of which the ring at the end of the chain may be affixed by means of notches or of a pin, called a cheek, and the plow let down to a greater depth below the axis, or taken up.

Viewed in its horizontal direction, the beam has not the same tendency as the body of the plow, but rather inclines a little to the right. If the beam were placed in an exact line with the left side of the body of the plow, the share would not incline sufficiently towards the left, and would have a tendency to rise out of the soil. In constructing a plow, however, if sufficient care has not been taken to avoid this inconvenience, some means must be sought to remedy it; this is effected in wheel plows by placing the beam on the left side of the axis, and in others, by attaching the line of draught to the last hole on the right side of the bridle or regulator. But this effect will always prevent the possibility of cutting wide furrow-slices, even when such a proceeding appears to be advisable. As the beam is always a little smaller towards the foremost end, the wood is raised a little on the left side, while the opposite one is left perfectly straight.

The *handles* are those pieces of wood by the means of which the laborer introduces the plow into the soil, and corrects its deviations. Properly speaking, these are not used for the purpose of directing the plow, since, if it is well made, it will of its own accord pursue the path traced out for it. But when this instrument encounters some extraordinary obstacle, and one or more of its parts receive a shock which causes it to deviate from a direct line, it is then the office of the plowman to restore it to its proper position; but this must not be done by needless violence, but by a temperate and gentle exertion of strength. He ought to be so well accustomed to his duty as to be able to feel at once, by the sensation communicated to his hand, any deviation of the plow, however slight, and to be ready to remedy it, as it were almost instinctively, by an opposite movement.

Plows are made with either one or two handles, but, in point of fact, only one is necessary, namely, the left. Most agriculturists prefer wheel plows with only one handle, in order that a plowman who is accustomed to the use of them may have his right hand at liberty to use the whip, or that little instrument by means of which he removes roots or rubbish and earth which may be collected on the mould-board, or in front of the plow. Two handles, they affirm, render the plowman idle, and encourage him to lean on the plow, by which the labor of the draught cattle is considerably augmented. Nevertheless, it cannot be denied that the right handle is occasionally useful, that it assists materially in fixing the

plow in the soil, and in overcoming those obstacles which it encounters more quickly; and that, moreover, when this handle is held with a firm grasp, and with the right arm slightly bent, it acts in opposition to the earth, which, resting heavily on the mould-board, might easily cause the plow to incline toward the left, and render the slices uneven.

In common wheel plows the handles are placed at the hinder extremity of the plow, in order that by their means a sufficient degree of perpendicular pressure may be exercised upon it when it is desirable that the instrument shall penetrate more deeply into the soil; but should the soil be hard, the only effect produced by this pressure will be the raising of the point of the share. In English plows without wheels, the handles or stilts are brought more forward toward the front of the instrument, and placed at the point where it experiences the greatest resistance: on their reäscension at the back of the plow they are extended to a sufficient and suitable length. By means of these levers the laborer, without any great degree of exertion of strength, is enabled to resist all the deviations of the plow.

But the slightest pressure on these handles is here so sensibly felt, that the chief difficulty attending the use of the plows, is to make the plowman abstain from all violence, and from all sudden jerks of the hand. In general, men who have never plowed before, are easily taught the use of swing plows, and how to guide and manage them; whereas, those who have been accustomed to this operation all their lives, almost invariably commit the great error of leaning too heavily on the handles. As soon as a person is accustomed to manage the handles, to raise the hinder part of the plow a little when it seems disposed to quit the ground, and to press upon it when it penetrates too deeply, the direction of these swing plows becomes so easy that a child of twelve years old might manage them. It is only when the land is unequal or hilly, or when the plow meets with some unexpected obstacle, that the plowman is obliged to have resource to the handles, in order to keep the plow in the direction which it ought to go. Many persons have imagined that it is difficult to turn plows without wheels, when they have reached the end of the piece which is to be plowed, and when it becomes necessary to commence a fresh furrow; but they are quite wrong, for there is no other plow with which this can be so easily effected. All that is requisite to be done is for the laborer to incline the instrument on the right side, suffer the draught cattle to pull it round, right it by means of the handles, raise these latter a little, in order to enable the share to penetrate the soil, and then allow the plow to proceed on its course.

It always ought to be possible to regulate a plow so as to cause it to make the furrows of the width and depth which we wish them to be. The arrangement by means of which this is effected, is attached to the extremity of the beam, and is very different in wheel plows from those which are without wheels. In the former, when the part of the beam which extends from the point where it rests on the axis, to the body of the plow, is elongated, the plow has a greater tendency to penetrate into the earth; whereas, if it were shortened, the contrary effect would be produced. Those holes which are observable in the middle of the beam, are intended to effect this elongation or a diminution of length. But where the desired effect cannot thus be produced as perfectly as is necessary, a regulator is generally placed in front of the throat, or wedges are inserted at the hinder end of the beam, by the means of which this latter may be raised or lowered. The regulators are constructed in various ways. In wheel plows, on the mechanism of which greater care is usually bestowed, their effect may be graduated in an almost insensible manner. They are often so contrived that by these means the breadth of the furrow-slice may be increased or diminished: for example, if the beam is more inclined to the right, the share will be turned more to the left, and will cut a wider slice. In order, however, to cut the furrow-slice of any considerable width, the point at which the draught power is attached to the fore wheels must be altered; and this is effected by means of a regulator. By means of the teeth of this last-mentioned piece, the traces and the wheel carriage may be shifted to the right or the left at pleasure. The contrivances attached to plows to effect this purpose are numerous and various; but there is no occasion to give a special description of each. The most simple, certainly, are the best; and this will be found in the description of the Norfolk plow,

by Dickson. This is the most perfect wheel plow of any with which I am acquainted. The regulator is made of iron, and, consequently, is rather more expensive. Nevertheless, if we come to consider on the one side how much more durable iron is, and with what rapidity the bar may be suspended in the notches; and, on the other hand, how apt inventions of a similar kind are to break when constructed of lighter materials, and the difficulty in making them sufficiently firm, we shall come to consider it as very economical. The Norfolk plow is, however, only calculated for very light plowings which do not exceed three inches in depth.

In order to regulate the depth to which a plow shall penetrate the earth, it is only necessary to raise or lower the line of draught attached to the bridle at the extremity of the beam, or to advance this point or draw it back. If we wish to determine beforehand, according to a given hight taken from the point of draught of the animals, and according to a certain length of traces, to what depth the plow will penetrate the soil, a straight line must be drawn from the former to the body of the plow, passing by that point at which the traces are attached to the beam. The plow enters the earth at the place where this line falls. The lower the point to which the traces are attached, the nearer will the extremity of this line approach the point of the share; and the higher it is, the farther will it rise on the body of the plow. But in using swing plows, it is quite sufficient to know that by lowering the point to which the traces are attached, the plowings will be rendered more superficial; and that by raising it, the depth to which the plow penetrates the soil will be increased. The most superficial examination will convince any person who has a swing plow before his eyes, that this raising or lowering can be effected with the utmost facility and promptitude.

By means of this regulator a tendency may also be communicated to the plow, which leads it to incline more to the left or the right; or, in other words, to cut larger or smaller slices. To effect the first, the bar is attached more to the right; and to effect the second, more to the left.

Although the use of wheel plows is so widely different, that in some parts of Germany the farmers have no idea of plows without wheels, these latter are very useless appendages, excepting in a very few isolated cases. They increase the weight which the draught cattle pull, without producing any advantage, and seem to owe their invention to erroneous views, and the introduction to their ingenious appearance.

Wheels never can contribute to lighten the load; for when a plow is properly regulated, the extremity of the beam scarcely touches the axis. It is only when some defective tendency of the instrument drags it into the soil, that the beam rests heavily on the axis, and then the resistance opposed by the plow is rendered greater from the line of draught being interrupted and receiving three distinct tendencies: one from the point of draught to the under part of the fore wheels; the second, from this point rising towards that point of the beam to which the bridle is attached; and the third, from this latter point to the share.

It is a very general opinion that the addition of wheels renders the motion of the plow firmer and straighter, and that by their assistance the instrument is better able to resist those obstacles which might turn it aside from the direction which it ought to follow, and that they render the task of guiding it less difficult. But they can only produce these effects by allowing the beam being made longer, so that the length of the lever may give it sufficient strength to resist the deviations of the share; and in this case, when the resistance is of a nature which admits of its being easily overcome by a plow, it will be possible to surmount it quite as easily with a swing as with a wheel plow; and as the shortness of the beams of swing plows is the chief cause of their being so liable to be thrown on one side, when they are well made they are so constructed as to give the laborer sufficient command over them to prevent this deviation, an advantage which cannot be given on wheel plows. Even when this resistance is not of a nature to admit of its being easily overcome by the instrument, swing plows are preferable, because they run much less risk of being broken by the efforts of the cattle, in consequence of their springing, as it were, aside; and besides, a plowman who is accustomed to guide them, will feel at once, by the sensation communicated to his hands, whether or not it is possible to overcome the obstacle which presents itself: and can, therefore, by means of a slight pressure, assist

the instrument, and if necessary turn it aside, so as to prevent it from sustaining any injury.

I used to be of opinion that a large wheel plow was best adapted for the purpose of tilling stony, uneven ground, full of roots, or of clearing an uncultivated soil; but experience has convinced me of my error. I have broken up land filled with roots of trees, by means of Small's plow, and Baily's, and with a draught power far less than that which would have been requisite to work a large wheel plow. I have tilled land of this nature with only two horses, on which it would have been impossible to make use of a large wheel plow, without attaching at least six horses to it. I must, however, confess, that the chief cause of the advantage of these swing plows arose in part, if not wholly, from the coulter having been firmly fixed, in the manner recommended by Small.

If plows without wheels lose a little of their steadiness from the motion which they experience at the extremity of the beam, this inconvenience is more than compensated by the power and command which the laborer has over them. By means of the slightest pressure he can cause the plow to incline towards the left, and thus cut a wider slice; or, by turning it towards the right, he can dispose it to quit the soil. By raising the handles a little, he can cause it to penetrate deeper into the ground; and by lowering them, prevent it from entering any farther, or cause it to raise out of the soil altogether. Where the surface of the soil is level, he has no occasion to use any of these precautions: all he has to do is to suffer the instrument to follow its natural course. The great superiority of swing plows over wheels is particularly striking on uneven, hilly ground, which is full of risings and declivities. On such land wheel plows act unequally, and trace furrows of various depths. This may easily be accounted for. When they ascend a rising ground, the fore wheels are higher than the body of the plow, and, consequently, the point of the share is lifted up: in this case it only cuts a very thin slice, and sometimes rises out of the earth altogether. On the other hand, when the plow is going down hill, the fore wheels are lower than the body of the plow, and then the share penetrates too deep. These inconveniences can only be remedied by regulating the plow in a different way every time the inclination of the soil varies; all endeavors made by the laborer to remedy it in any other way will be perfectly useless. This is never more evident than when a field, divided into ridges, is plowed across with a wheel plow: as the fore wheels ascend the rising surface, the share hardly touches the ground; on the other hand, when they descend into the furrow, it enters too deeply. Now, with a swing plow, the plowman can, by means of the long handles with which it is furnished, overcome these obstacles, and trace an even furrow without much difficulty or the exertion of any great degree of strength.

All plowmen are well aware of the great difficulty there is in making a wheel plow penetrate a hard, tenacious soil. Not one of the numerous contrivances used under similar circumstances, nor of the alterations which are made in the plow every time it is put in the ground, nor the pressure on the instrument effected by the conductor which ascends to the beam, nor the bringing the head nearer to the hinder part of the perch, not one of these remedies is at all efficacious, and the operation is either badly executed or cannot be performed at all.—A plow without wheels, having a share which is, perhaps, a little more pointed, ought, when the handles are slightly raised, to penetrate even a barn floor, if such a thing were necessary, and if the moving power attached to it is sufficient to cut the hardest soil; indeed, provided that the requisite number of draught cattle are employed, no degree of draught or hardness of the soil can impede its action.

The greater the simplicity of the mechanism of plows without wheels, and the increased solidity of their parts, cannot be overlooked; they are less liable to be damaged or injured, and thus that time is saved which is too often necessary to be devoted to repairing such implements.

In wheel plows, the wheels are not always well made; there can be no doubt that large, well-rounded wheels are far superior to those which are small and ill constructed: this advantage is not, however, very great, and does not contribute so much to diminish the resistance as some persons think.

Sometimes the wheels move round on immovable axletrees: at others they are affixed to the axle, or to an iron axletree, which itself revolves in the body of the

wheel carriage. The latter are generally preferred, especially when the wheels are low, either because the axle will not then be so soon worn out by the friction of the soil, or because, in the other case, it is imposible to prevent some portion of earth from insinuating itself between the smallest wheel and the axle on which it turns; this plan is not, however, without its inconveniences.

Sometimes the wheels are of equal dimensions: at others, the spokes of the right wheel, or that which moves in the furrow, are increased to the depth of the furrow or nearly so. When the wheels are of equal diameter, the fore part of the plow is necessarily placed in an oblique position. This obliquity increases the friction so much, and inclines the fore part of the beam so much towards the right, that this plan is only practicable for superficial plowings of not more than three inches in depth. Whenever it becomes necessary to plow the soil to a greater depth, the diameter of the right wheel must be proportionably increased in order to bring the wheel-carriage into an horizontal position. But if two wheels of unequal size are affixed to the same axle, at each revolution the smaller one will remain behind, and has to be dragged after the other, for two wheels of unequal dimensions moving on the same axis have not an equal progressive motion. The right wheel, which is largest, keeps in advance of the other, and tends to throw it on the left side; it consequently rubs against the unturned soil, and is thus repelled, so that the wheel carriage of the plow vacillates and the friction is considerably augmented. If the wheels are different in diameter, it is highly requisite that at least one of them should move round the axle.

An inequality of the wheels is likewise attended with considerable inconvenience when we come to plow with raised furrows. If the furrow already raised must be still higher, at the first motion of the plow, the right wheel which stands highest is immediately placed in a more elevated position, and the fore part of the wheel-carriage so much inclined that it frequently turns over, and it is impossible to fix the share in the soil; it likewise often happens, when the soil inclines on the side of the furrow, that the right wheel is obliged to move in the preceding ridge. It is also found that the first and last furrows of large raised ridges are always badly executed, unless every care is taken to arrange the plow so that it shall be capable of performing them properly, which is a matter of great importance in this mode of tilling land.

These are some of the inconveniences attending the use of plows with fore wheels, which are at best very useless appendages, and serve only to increase the resistance and the friction.

The only case in which I can give the preference to wheel plows is, when they are used not for the purpose of breaking up rough, uneven, and tenacious soils, which oppose considerable resistance to the action of the instrument, but only when they are employed for the purpose of performing shallow plowings with large ridges on a flat surface. Here the fore wheels will prevent the instrument from penetrating too deeply into the soil, and cause it merely to pare the land.—A wheel plow may be more easily arranged so as to make it cut larger slices than a swing plow; indeed, this can only be effected with the latter by a peculiar construction.

Sometimes a foot, similar to that on which the beam rests, is affixed to the plow instead of wheels; and the lower part of this is terminated by a kind of hoof, or by a little wheel which occupies the place of the coulter. At other times, two wheels are affixed to the back of the plow.

The plow most generally used in Belgium is of the former description; and Schwertz, in his account of the Agriculture of Belgium, maintains that it is far superior to all other plows. The body of this instrument certainly is excellent in form; but the foot on which its foremost part rests, and which drags through the soil, necessarily intends to increase the friction. It can hardly be said to contribute to steady the motion of the plow, and it is likely to prevent the plowman from having as much control over the instrument as he otherwise would. The only advantage which can be derived from it, consists in its tendency to diminish the effect of any erroneous motion made by the plowman. This addition appears to have been made solely because the inventor feared that it would be impossible to teach laborers the proper method of guiding these plows. This foot cannot be used on uneven ground; for as soon as it touches an elevation, or a stone, the point of the share rises out of the ground, or, at any rate, to the surface of the soil.

It is always better to substitute in place of this foot a small wheel, similar to that on the skimming plow. This wheel occasions less friction. A similar wheel has also been adjusted to the front of the body of the plow, in the place of the coulter, and the outside of it sharpened. It is thought that by this means the separation of the slice, especially if it is turf, is facilitated; but it cannot be denied that it is very difficult to cause this wheel to penetrate the ground. In fact, it can only be effected by giving the share too great a tendency to enter deeply into the soil, or by means of fore wheels, which depress the beam. Both these methods augment the friction and the resistance, without procuring any advantage which would not have been attained equally as well by means of the coulter.

Endeavors have also been made to add a small wheel to the hind part of the plow, in order to diminish the friction of the heel at the bottom of the furrow. The inconvenience of this addition is manifest.

A wheel with iron spokes, and without joints, has also, occasionally, been affixed to plows. This is placed at the side of the mould-board, across which its axle passes, and is supported at the opposite end on the bottom of the left handle. The outer extremity of the spokes are made in the form of a shovel; and it is pretended that by this contrivance, the earth of which the slice is composed is turned over, and thoroughly loosened and divided. In light, sandy soils, this wheel divides the sand very well, and produces the intended effect. But the friction is so much increased, that it becomes necessary to support the plow on the opposite side to prevent it from turning over. On argillaceous and tenacious soils, where this invention might possibly be useful, it is incapable of producing any effect.

Among the numerous improvements and additions which have been made to the plow, I shall only notice the following.

As the reversion of the slice cannot always be effected in a sufficiently complete manner, a movable plate is added to the hinder part of the mould-board at that part where it rises above the earth, or a triangular piece, which can be projected forward by means of a screw, is joined to this part by means of hinges or of thin, flexible plates of tempered steel; the screw passes from the inside through the lower part of the handle of the plow opposite the back of this movable piece, and can keep it in any required degree of inclination, which will enable it to overcome all the resistance of the double plows, of which we shall presently have to speak.

There is no doubt that it may be productive of much benefit, but this is not obtained without a considerable increase of friction, and without requiring, on the part of the laborer, a constant counter pressure to prevent the plow from being turned over. It has been asked if the reversion of the slices could not be much more completely effected by a man walking behind the plow than by having recourse to any of these improvements, which are very apt to get out of order. A somewhat similar effect is obtained from the *elongated Belgian mould-board*, which is composed of a board that serves to lengthen the mould-board, and of a piece of hard wood which forms the handle of it. This elongation is affixed to the body of the plow by means of a hook which fastens into a ring placed behind the mould-board. A young lad holds the handle and stands in such a position as to cause the elongation to form with the mould-board a more or less obtuse angle. He advances in a line parallel with the plow, and raises or lowers the handle according as the resistance of the slice appears to require it. This addition ought to be regarded as a very beneficial elongation of the mould-board; it certainly is exceedingly useful in deep plowings when the farmer wishes to plow his land in very shelving ridges, and likewise when he breaks up turf which offers a considerable resistance to the action of the plow, or can only employ one animal to draw the instrument.

Various kinds of coulters have likewise been affixed to plows, for the purpose of dividing and cutting the slice before it is separated and turned over by the plow; and these have been affixed to the beam by means of a piece connected with it. On tenacious soils this addition may be productive of benefit; but as I have never yet made any trial of it, I cannot venture to assert that it will not also be attended with some inconveniences.

Plows having a movable or sliding mould-board which can be shifted alternately from one side of the sheath, or head, to the other, have the advantage of

being able always to throw the earth on the same side, and, consequently, of plowing the land flat without any inequality or trace of ridges or furrows. When the first furrow has been traced and the slice turned over to the right, the mould-board is shifted to the opposite side; and thus the second furrow is traced close by the side of the first, and the slice of the second rests upon that of the first. These plows are constructed in various ways: the mould-board is often united to the board which closes the left side of the plow, and forms with it an angle of about forty-five degrees, the apex of which is in front of the throat or neck; these two boards are fixed there by means of a movable peg or pin, and, at their hinder end, are held on by means of an iron bow, which keeps them at a suitable distance. By means of this arrangement, one or other of these boards can alternately be put in action by pressing the contrary one against the head; and they are maintained in their proper position by an iron bolt which is placed in one of the holes bored in the bow. Plows of this kind can likewise be employed for the purpose of making furrows for draining by placing the two mould-boards at an equal distance from the head, so that they shall raise an equal quantity of earth.

But, in general, the mould-board of this kind of plow is detached, so that, when it is necessary to alter the position, it can be removed altogether; although only affixed to the plow by means of hooks, it is yet sufficiently firm.

Occasionally, plows of this kind have only a little ear instead of a mould-board, and that is curved and turned in various ways, and consequently, throws the earth more or less to the side. It will easily be understood without the necessity of my making any remarks on the subject, that by this contrivance the soil is very imperfectly turned over; besides, such plows require to be constantly inclined to one side. All plows of this kind ought to have a share with two sharp edges similar to those of an iron lance.

In the best of this kind, in those by means of which the land can be plowed to a certain depth, the coulter is so contrived that the blade shall be able to turn to the right or the left as may seem best. The manner in which this is effected varies in different instruments; but in all those that I have seen, it appears to be liable to frequent alterations and injuries, so that, in general, it accomplishes the purpose it is intended to effect but very imperfectly.

It is, in general, almost impossible to render these plows very straight or even on the side which comes in contact with the unturned soil, and yet that is a very essential point as regards the firmness and regularity of the motion of the instrument. The friction attendant on their action is therefore very great, and, consequently, when persons assure us that these plows move very easily, and do not require any very great draught power, we are necessarily led to infer that they can only have been used on light soils, and for very superficial plowings. I have not as yet seen any plow of this kind that acts well, excepting the Mecklenberg *binot;* I therefore always prefer this instrument, on account of its simplicity. Plows having movable mould-boards are very much used in countries in the neighborhood of the Rhine.

At various periods, public attention has been called to double-furrow plows having but one beam, to which are attached two shares and two bodies; these are drawn by one team, advanced parallel with each other, and are guided by a man stationed behind. Latterly, two plows of this kind have been presented to the public—one invented in England by Lord Somerville, and the other executed at Vienna. I have an instrument of this nature which was made in England, and is very similar to Lord Somerville's.

It is evident that this kind of plow must necessarily require a moving power considerably greater than that which would be sufficient to draw a more simple plow; and, consequently, it can only be productive of any saving when the team ordinarily used has more draught power than is requisite to put in motion a common plow. This certainly may occasionally happen; but when, as is generally the case, the double plow requires four horses instead of two, nothing can be gained, because two men will likewise then be required, one to guide the instrument, and the other to drive the animals.

I have several other objections to adduce against the instrument which I possess, although it is very well constructed. It is very difficult to manage when it becomes necessary to turn it at the extremity of the furrow: it cannot easily be

made to enter the soil; and, in fact, when the ground is hard this becomes almost an impossibility; besides, the weight of earth which rests on the two mould-boards inclines the plow so much towards the left, that the whole strength of the plowman's right arm is not sufficient to keep it in its place; and thus the right hand body only turns up the soil very superficially, or is not fixed in it at all: these circumstances have induced me to give up the use of the instrument altogether.

Trenching plows, on the other hand, have two bodies placed in a line with each other, but the one working four or six inches deeper than the other. The front one is generally higher, smaller, and weaker than the hinder one: it only pares or skims off the surface, separating a slice of earth, and turning it over into the furrow made by the main body of the instrument; the hinder plow raises another slice, which it takes from beneath the place which has just been uncovered, and places it on the slice turned over by the first plow; and thus the whole depth of the furrow is thoroughly turned over. I have often made use of a plow of this kind which was manufactured in England, with all possible care and attention, and in which there was no want of hooks or joints to connect the parts with each other; but the greatest depth to which it could be made to penetrate in land of a moderate stiffness was seven inches, and the instrument did not appear to be able to bear that amount of pressure which was necessary in order to overcome the opposing weight of earth. On calculating the expenses attendant on this plow, and of the team required by it, I became convinced that I should have obtained results at a much cheaper rate by using a common plow and coulter, to be followed by men provided with spades to dig up the bottom of the furrow to the required depth; an operation of which we shall presently have to speak. Then the plowings are not required to be so deep; and one plow following the other in the same furrow will produce a similar effect. I cannot, therefore, recommend this expensive instrument, although in many cases, and especially on sandy soils, it may be very useful.

Nevertheless, under some circumstances, and particularly when a clover field has to be plowed up, or a piece of land which has lain for a considerable period in repose, but not very hard, and which does not require very deep plowings, this operation cannot be too highly recommended. This slice is cut horizontally through the middle, and its surface is turned over and lies at the bottom of the furrow, where it is afterwards covered by the other half of the slice which is free from weeds. A *trenching* or *cutting plow* is generally used for this purpose, which does not penetrate very deeply, and the upper part of which is only composed of a coulter, a share and a small ear. But, in by far the greater number of cases, that simple instrument of which I have given an account in my descriptions of agricultural implements, under the name of a *paring* or *skim-coulter plow*, will fully answer every purpose required. I now invariably use it for plowing up my clover fields, and I find not only that all the plants are thoroughly buried, but also that the soil is perfectly loosened, and that it is not necessary to bestow a second tillage on the land to prepare it for the autumnal sowings, even when the clover is in its third year, or cattle have been pastured on it. In all other cases the land would require three plowings; therefore, one crop more of clover may be derived from it when this instrument is used, than could be obtained under any other circumstances.

There is also another instrument of a similar kind, in which the ear which raises the upper part of the slice from the bottom of the furrow, and turns it over, is affixed in the front of the throat by means of a peculiar bar, which enters into the beam of the plow. The English farmers, who consider this to be one of their best inventions, and are quite right in so doing, call it a trenching plow.

That termed the *Preussische zogge* is a very good kind of plow, and somewhat similar to those used in this country, having no wheels, and being, like the *binot*, supported and drawn by the beam which is suspended to the yoke of the oxen. It cannot be denied that this is a very light instrument, and that its construction renders it able to overcome resistance and diminish friction as much as possible. It penetrates the soil like a pointed wedge, and the lower mould-board throws off the earth very well. It also turns over tenacious soils with great facility, and is peculiarly adapted to them; as for lighter land, it divides and turns it over without forming any ridges or inequalities.

The instrument itself costs little; but as it is very fragile it is always necessary to have twice as many of them as can ordinarily be used, in order that the operations of tillage may not be impeded by the occurrence of accidents. This point might, however, easily be remedied; and if the instrument were constructed with more firmness and solidity, the use of it would become less expensive; but its principal defect, or rather the chief objection which is urged against it, is the great difficulty in guiding it; indeed, it can only be managed by persons accustomed to the use of it. It is almost impossible to introduce it into any district, unless persons can be engaged who have been habituated to the use of it from their earliest youth. If not properly managed it leaves unturned ridges between the furrows, which it only covers with new earth. The inhabitants of East Prussia have reason to be attached to this plow, since it was first introduced among them.

The second class of instruments, by means of which the soil is prepared for the reception of the seed, comprises the *binoirs*. The characteristic difference between binoirs and plows consists in the former not having a mould-board placed slantingly on their side: many persons in Germany have imagined that it consisted in the absence of the fore wheels and wheel-carriage.

The *binoirs* vary in shape and make, equally as much as the plows do. The greater part of the Roman plows were of this kind, and many such will still be met with in Italy, Spain, and France; but as there are not any of all these binoirs, either ancient or modern, which can surpass ours, I shall content myself with describing them.

The *Mecklenberg binoir* thus far resembles a plow: it partially turns over the soil if guided so as to produce that effect. The following are the parts of which it is composed:—1. A pointed, triangular-shaped *iron*, somewhat resembling a spade: this is united to the 2d part, the *ear*. The earth raised by the iron slides obliquely on to the ear, on each side of which it falls, unless the binoir is held in an inclined position; by means of a slight inclination the laborer can cause the earth to fall on which side he pleases. The handle, or elongation of this ear, passes across the beam, and is there fastened by means of wedges; the under part of the ear rests on the sole of the binoir, or that part which slides along the bottom of the furrow. By means of wedges the ear can be raised or lowered according as it appears necessary that the iron should penetrate more or less deeply into the ground. 3. The *beam* is formed of a piece of wood naturally curved in the proper direction, and which is chosen for this purpose with great care. The hinder part of it rests in a mortice hollowed out for its reception in the head; and the handle, which passes athwart and enters the head a little farther forward, keeps it in its place, and serves to direct it. 4. The *head*, the object and form of which will be fully explained in what we have to say respecting other portions. 5. The *handle*, by means of which the instrument is directed. If it is intended that the binoir should throw the earth to the right during its progress, the laborer grasps the handle with the right hand, and inclines the instrument towards that side. Afterward, when he is returning, he takes the handle in his other hand, and inclines the instrument towards the left; by which means the earth falls into the preceding furrow, and fills it up. If the binoir has to be drawn by oxen, an elongation is made to the beam by means of a ring and a hook, the foremost extremity of which is affixed to the yoke of the animals so allow a lateral motion. On the other hand, if it is to be drawn by horses, which does not, however, often happen, a shaft is adapted to the extremity of the elongation of the beam, and to this the horses are harnessed. When a pair of horses are to be used, the wheel-carriage and fore wheels of a plow are attached to the binoir. No person who is acquainted with this instrument, and with the manner in which it is constructed, can for a moment doubt its efficacy in tilling the soil, in thoroughly dividing all its particles, and completely tearing up all kinds of weeds; but it turns over the slice very imperfectly, and has also another fault, namely, it does not move the earth throughout the whole width of the furrow, but leaves a ridge of unturned earth between each, which it certainly covers with fresh mould. I have never seen this instrument in operation without being struck by this defect in its action.

All good agriculturists in Mecklenberg agree that the binoir is not adapted for all kinds of operations; and that, especially when pasture grounds are to be

broken up, or fields tilled that have borne any kind of grain, all other plows are to be preferred. On the other hand, it is peculiarly adapted for the second or third plowings given to such land; and also for that tillage which precedes the sowings, when the seed is deposited in open furrows. In the latter case, the following is the only inconvenience attending its use: the ox on the right passes over the newly tilled land, and treads it down with his hoofs; and thus holes are formed in which the seed collects. Judicious agriculturists will avoid this inconvenience by making use of the binoir with a wheel-carriage attached to it, and causing the ox to walk in the furrow. Land should never be tilled with a binoir in the same direction with the preceding plowing, but always in an opposite direction; by this means the binoir cuts through and divides the slices turned over by the previous operation. It is a very good plan to use the plow and the binoir alternately on tenacious soils, provided that a harrow with teeth projecting forward is likewise used. It is on this account that the operation of plowing is always so neatly performed at Mecklenberg; in fact, it is scarcely possible to find a garden in which the soil is more thoroughly loosened, cleaner, and neater, than it is in a Mecklenberg fallow. The only inconvenience which I can discover, attendant on the alternate use of the plow and binoir, is, that it is scarcely possible to get the same men and cattle to work with both these implements. Persons not accustomed to the use of the binoir find great difficulty in managing it, while those who are habituated to guiding it can frequently work with it for ten hours without being fatigued. It is, also, hardly possible to employ the same draught cattle, and especially oxen, to draw a plow and a binoir alternately—because, in the use of the former, the right-hand ox walks in the furrow, and, when working with the latter, it has to pass over the newly plowed soil immediately at the side of the furrow: when the instrument is turned, the ox on the left will have to walk over the plowed land, while the other passes over that which is untouched. Whenever it is practicable to have a separate set of men and beasts for each of these implements, the alternate use of them will be found to be attended with manifest advantages.

The binoir is best adapted for soils of a moderate degree of consistency; on very compact and tenacious land, the use of it is attended with considerable labor and difficulty, and a tolerably good plow is far preferable. This instrument is apt to divide light soils too much, and to render them too loose and friable.*

The facility and promptitude with which the binoir may be turned aside or lifted up, renders it peculiarly adapted for the tillage of stony land, or that in which there are many obstacles to be avoided or overcome. This instrument is the best that can possibly be used for the purpose of plowing abrupt declivities or hilly ground; and is far more convenient than any other kind of plow, because it turns the soil over much easier on the side of the declivity, without throwing it too low. Land may be plowed with it in any direction, whether horizontally or obliquely, up or down hill, and even in a circle round any obstacle which cannot be overcome.

The *Silesian binoir* (der Schlessische Ruhrhaaken), as may be seen by the various descriptions of it which have been published, varies much in its form.—Many of the binoirs in Silesia are very similar to that which I have just described. But it is not of those I would speak, but of others, which, instead of the sole that slides over the ground, have only a spade-shaped iron, by means of which they turn up the soil; and two handles behind, for the purpose of guiding them.

The only use of these instruments is to alternate with the plow, for the purpose of breaking up the soil across the plowings, and for this purpose they are perfectly well adapted.

The *Livonian binoir* is an implement which acts on the soil by means of a bifurcated iron, which, being curved forward, penetrates the ground with its two points, and loosens it. Another shovel-like iron, placed at the end of a handle, and which resembles in its shape those which are used to cleanse plows from dirt or mud, only being a little larger, serves to throw the earth a little on one side. This latter piece is fastened by means of a pin, and may be turned either

* A full and detailed account of the Mecklenberg binoir is given by *Schukmacher*—a man to whose researches the science of Agriculture is very much indebted—in his work entitled "Abhandhung vom Haaken als einem vorzuglichem Werkzeuge anstall des pfluges." Berlin: 1774.

to the right or to the left, according as it is requisite to throw the earth on one side or on the other. If we except these two pieces, this plow does not contain any portion of iron; there are no hooks, and the whole is fastened to the pole to which the horses are harnessed, by means of cords.*

One circumstance relating to this binoir, which renders it exceedingly hard work for laborers who are not accustomed to the instrument, is, that the hinder part requires a great deal of leaning or pressure, without which it penetrates too deeply into the soil.

The *cart binoir* is an instrument which runs on wheels, and, when once entered into the soil, requires no guidance; in general, the laborer mounts upon it or upon a horse, and thus goes forward with it. It is chiefly used in the low countries in the neighborhood of the Vistula, and is far better adapted for the cultivation of flat alluvial soils than any plow. This instrument is not, however, adapted for breaking up land which has been pressed down and hardened by wagons; such, for instance, as can easily be tilled by one of Baily's plows, drawn by a pair of oxen; and, if not adapted for breaking up argillaceous soils, it is perfectly useless, for the Mecklenberg binoir is fully capable of performing everything that is requisite for the subsequent tillage.

The third class of agricultural implements comprises those by means of which the soil is not turned over or plowed very deeply, but is well cultivated to a depth of three or four inches, and with great saving of time and labor; by means of which the soil is thoroughly pulverized and mixed to that depth, and the seeds of all kinds of weeds destroyed, by being in the first place brought to the surface and made to germinate, and subsequently destroyed, and the roots of other weeds torn away or killed by being cut in pieces. It is not until latterly that this class of instruments has become known to us. We are chiefly indebted to the English for the discovery and invention of them; indeed, the mechanical talents and ingenuity of that nation have tended very materially to improve the science and practice of Agriculture. There is a great variety of these instruments used in England. Every farmer employs the one best adapted to the nature of his land, and to the end which he has in view. Occasionally he makes such alterations as seem best to him in their construction; but these modifications are seldom of any great importance. All those persons who invent or improve such instruments, almost always name them afresh; and it not unfrequently happens that the same instrument will receive a different appellation in each district where it is used. We must not, therefore, imagine that, because we hear it lauded under another name, it is a different kind of instrument. If we wait until we can see or obtain a circumstantial description of it, we shall generally find that it differs very little from those we are already acquainted with. The different instruments appertaining to this class may be ranged under the following denominations:

1. *Scarifiers.* In general these instruments are armed with curved knives, somewhat similar in form to the bill-hooks or pruning knives used by gardeners. These knives are affixed to bars passing across a wooden frame, resembling that of a barrow: they are not arranged behind one another, but in such a manner that each one shall trace its own line separate from any of the others. The chief use of scarifiers is to penetrate the soil and divide it to a certain depth, and to cut through argillaceous soils, and loosen them more deeply than a harrow could, and turn up the under portions and bring them in contact with the atmosphere. Cattle are occasionally harnessed to the instrument itself; but in general a wheel-carriage and fore wheels are affixed to it,and two handles are attached to the back in order to weigh it down and cause it to penetrate the ground. At other times, small wheels are added to each of the angles of the scarifier, which can be raised or lowered at pleasure, so as to give the instrument a greater or less tendency to enter the soil.

The same frame may be made to receive other irons; for example, an extirpator may be transformed into a scarifier, by substituting the knives which constitute the latter, for the shares or feet which belong to the former.

2. *Horse-rakes, scrapers, leveling plows.* I give them this latter name, because they act on the soil in the same way as the blade of a plane, by cutting the earth horizontally to a depth of one or more inches below the surface, and dividing it. Those who are acquainted with the common horse-rake, which is used to keep the walks and alleys of large gardens clean, will be able to form a very correct idea of this class of instruments. The blade may be rendered more or less oblique, according as it is deemed requisite that it shall penetrate the soil to a greater or less depth. The frame to which the blade is attached is supported by two handles, and the foremost part of the beam usually rests upon a wheel: sometimes the fore wheels of a plow are affixed to these implements. They are chiefly used for the purpose of clearing from the ground the stubble

* A description of this instrument will be found in the work entitled "Anzeigen der Leipziger Œkonomischen Societen von der Ostermesse des Jahrs," 1804, A.

of corn crops, and tearing up the weeds which spring there. They are also used for the purpose of leveling land in which the earth has been heaped up round the roots of the plants which formed the last crop. They are principally used for this purpose in the county of Kent, where they are employed to give a certain degree of tillage to land after the bean crops have been gathered, and to prevent the soil from becoming infested with weeds during the period which has to elapse before the proper time arrives for plowing it, previous to the sowing. This operation may be performed very quickly, and does not require any very great degree of draught power. By means of it the soil may be prepared in a very short time for the reception of spurrey, buckwheat, radishes, &c.; because it frequently happens that at a certain depth below the surface of the earth is tolerably loose and light, and it is only the surface which requires to be divided.

3. *Hoes*. The instruments which are comprehended under this denomination, act on the soil by means of feet, teeth, or shares, more or less pointed or obtuse, and more or less horizontal or inclined, and which are shaped like a shoe or a goose's foot. They are intended to loosen the whole surface of the land over which they pass; and for this purpose the tines are arranged in two or three lines, so that no particle of the soil shall escape them, but every portion be thrown by the front row of teeth into such a position as not to escape the action of the hinder ones; and thus each clod may be repeatedly acted upon and broken. The *extirpator*, an instrument which is now very much used, and of the utility of which every practical agriculturist must be convinced, belongs to this class. This instrument may be made of various sizes. Where the land is very even, the number of feet on every rail may be increased: thus, six may be affixed to the back row, five to the front, &c. But where the land is unequal, it is better to make use of a narrower extirpator, and which has not so many tines. The draught power must, of course, be proportionate to the size of the instrument; and if four, or even six horses are requisite to put in motion a large extirpator, two will suffice for a small one. The more tenacious the soil, the more pointed must the tines be. It is also advisable to make the front row, those which are to open the ground, sharper than the hinder ones. The irons may be rendered flatter or more convex, or may be so constructed as to have several diverging points, according as the instrument is intended merely to move the land, or to divide it thoroughly and turn it over. The depth to which these tines shall penetrate the soil, may be regulated by raising or depressing the beam. In my opinion, the tines in the front row ought to be, at least, half an inch longer than the hinder ones, in order that they may penetrate more deeply into the soil, even when the beam is not raised. Without this precaution they do not enter so far as the hind ones, and frequently only slide along the surface.

There are few soils which will not be benefited by the use of this instrument. Several persons who have employed it with great advantage, have assured me that when the tines or shares are sufficiently pointed, it penetrates easily even into the most tenacious soils. The only places in which it cannot so well be used, are those where the surface of the ground is full of large immovable stones. When employed on such soils, care must be taken that the tines or shares do not break, or, at any rate, that others shall be at hand to replace those which are injured, and also that the points shall be strong enough to enable them to resist the action of four horses. Small stones will not impede this instument, even should they be too large to admit of their passing between the irons; all that is requisite to be done here is for the conductor to stop the cattle for a moment, and throw the stones on one side. It cannot, however, be denied that stony land wears out the shares very soon. On land overgrown with couch-grass, or which contains undecomposed lumps of turf, or potato haulm, or other things of a similar nature, the action of this instrument is certainly impeded; but still it can act, although not without labor and difficulty. In such cases, the laborer must lift up the extirpator now and then, and shake it well; or, should this not be sufficient, he must stop and clean it—an operation which is very quickly performed by means of an instrument similar to a small shovel, and which is also used with the plow.

The use of the extirpator is so beneficial, that it not only supersedes all plows which bestow a merely superficial tillage, but surpasses them in their effects, whether as regards the divison of the soil, the affecting of an admixture of its component parts, or the cleansing it from weeds: it is from its great utility in the latter capacity that it derives its name. Besides, with an extirpator having six tines in the back row, and drawn by four horses, and driven by two men, equally as much work can be done as would be effected by six plows, each drawn by two horses and driven by one man, and often more, because an extirpator moves more quickly than a plow. It is therefore evident that the use of this instrument is attended with great saving. When a piece of ground has been turned up to the requisite depth by a plow, the extirpator may be used with advantage for all the subsequent plowings bestowed on it, and a more complete fallow, and more free from weeds, will thus be obtained than could possibly have been procured by any other means; provided that this instrument is used in time, and the weeds have not been allowed to gain too great an ascendency. Besides, an extirpator distributes and

smoothes land much better than a plow, raising and dividing the soil on eminences, and with the assistance of a harrow subsequently spreading these portions over the hollows and lower spots: this effect is peculiarly apparent when it is alternately used in every direction. The extirpator may also be used for the purpose of burying the seed; but there is another instrument of which we shall presently have to speak, which is better adapted for this purpose. Provided that the land is tilled before the commencement of winter, the extirpator is fully capable of bestowing on it every preparation for the reception of the seed of any kind of grain, and especially of barley. By its action, the soil is pulverized to the requisite depth, and the necessary portions of nourishment brought within the reach even of the smallest of the germs. Land tilled in this way retains its moisture much longer than it does when the plow only is used—a point of no small importance in dry spring weather.

If a sufficient period is suffered to elapse between each of the operations of tillage bestowed by this instrument, those seeds of weeds which were enclosed in the clods broken by the first operation will germinate, and the plants produced by them acquire sufficient development to admit their being torn up and destroyed by the second. The roots of weeds are also brought into contact with the air and destroyed by being repeatedly torn and cut. The utility of this instrument becomes strikingly evident when land which has borne weeded crops, for which it received the proper plowing and cultivation, is, on the following spring, to be prepared for the reception of oats. By means of it, I have been able to succeed in raising good crops of large two-rowed barley, from very sandy land, on which this kind of grain could not possibly have succeeded if it had been sown in the spring after a single plowing. The extirpator may also be employed with great success on a broken up clover field, where one plowing has not been sufficient to divide and loosen the soil. When this instrument cannot be used, three separate plowings must be bestowed on such land, which necessarily tends to retard the sowings. The extirpator is fully capable of loosening a soil, and rendering it sufficiently friable, and will likewise destroy the roots of the clover.

Nor is this instrument conducive of less benefit to land which has been plowed up after bearing a crop of peas or vetches. It is well known that such land should always be broken up immediately after the crop has been gathered in; and, likewise, that it is then liable to become hard and infested with weeds, if not tilled a second time; but every moment is too precious to admit of time to plow it again. By means, however, of the extirpator, the surface may be renewed, and the soil so thoroughly loosened that it is ready for the reception of seed, without the necessity of any other preparation.

Lastly, I have derived considerable advantage from passing this instrument lightly over a field of potatoes, when these plants were just shooting up and bearing a few leaves. This operation destroys the weeds which have sprung up there, and causes the crop to be less infested with parasitical plants. Many persons have considered that this end is attained equally well by the use of the harrow, especially if after having planted the potatoes with a plow, the soil is left in the condition to which it was reduced by that implement. I agree with them that the ground should always be harrowed directly after the crop is sown, in order that the germination of all the seeds and roots of weeds that it contains may be facilitated, and that they may shoot up sufficiently high to admit of their subsequently being destroyed by the action of the extirpator. It is generally admitted that this operation cannot be performed when the potatoes are planted on narrow and raised ridges.

Various implements, furnished with teeth or prongs of different shapes, or shares, have been invented in Germany, for the purpose of cultivating and tilling the soil to a greater or less depth. These are constructed in various shapes, and are of different sizes; some being armed with large wide irons, others with small narrow ones, and having three, four, five, and even six rows of them. Some have a wheel carriage attached to them, while others are drawn by means of a stiff pole. D'Arndt, a man celebrated in this country for the superior skill and excellence with which his fields are sown and cultivated, makes use of several instruments of this kind.

The most celebrated agricultural instrument invented by D'Arndt, is the *sowing plow* (*saatpflug*), which produces an effect similar to that of the small Eng-

lish extirpator. The shares of this instrument are generally four in number, and formed like common plow-shares; they are fixed to iron legs, which are attached to bars about eight or ten inches apart. The beam passes through these bars, and like that of the extirpator, is adapted to a wheel-carriage, on which it can be raised or lowered, according as it appears requisite that the shares should enter deeply or superficially into the earth. At first, D'Arndt had appended small mould-boards or ears to each of these shares, in order by this means actually to plow the land and turn it over. But he subsequently became convinced that it was better without an addition which tended greatly to increase the amount of friction and resistance, and to clog the instrument with weeds and clods of earth without communicating to it the good qualities of a plow. This instrument is chiefly used for the purpose of burying the seed in land already tilled and prepared, and it is fully capable of effecting this purpose in the most complete and perfect manner. After the seed has been spread over land previously well harrowed, this instrument is so regulated as to cause it to penetrate to a depth of about two inches below the surface, and is then passed over the whole of the field. This is a very laborious operation for two horses and a man, but the seed appears to be better distributed than it is by any other means with which I am acquainted. After a slight harrowing has been bestowed on the soil, the seed will be found to be placed at a suitable depth beneath the surface of the ground, properly mingled with the soil, perfectly divided, and not laid in heaps or hidden under impenetrable clods, but placed in the situation most favorable to the development of its germ and the extension of its roots. Thus, therefore, by means of this sowing-plow at least one quarter of the quantity of seed otherwise required will be saved; many persons have assured me that it saves more than the half; besides, this instrument does the work of four plows with far less labor, accelerates the operation of sowing, and enables the farmer to choose the most propitious moment for the performance of it. I must, however, state that I have not yet used one of these implements, because my land is not sufficiently free from weeds to admit of my employing it with advantage.

The English have a great many implements of this kind, differing in form, but productive of similar effects. In order to divide tenacious soils better, and facilitate the entrance of the shares into the ground, a knife or coulter is sometimes placed before each of them, or knives and shares are made to alternate. Some of these instruments are so carefully and ingeniously contrived, that the shares can be moved farther apart or nearer together as occasion may require; but where this is the case, the mechanism becomes more complicated and the instrument more fragile.

Great care must always be taken to choose from this variety of instruments those which are best adapted to the end which it is proposed they should attain, and to the soil and circumstances of the undertaking on which they are to be employed. It is very ill-judged economy to refrain from the purchase of such as are calculated to fulfil the proposed end in the best possible manner; it not unfrequently happens that the advantages arising from the employment of them are so great that their cost is repaid in the course of the very first year, nay, sometimes in the very first season.

This observation applies particularly to the sowing plow, which more than repays its original cost by the quantity of seed which it saves. It will hardly be believed that there can be among agriculturists men of such narrow minds, or who are so little sensible of their actual interests as to grudge the sum which such an instrument costs, although fully sensible of all the advantages arising from the employment of it; or authors so blind and bigoted by prejudice and avarice as to defend and advocate such niggardly and futile policy. The poorest mechanic does not hesitate to purchase the tools adapted to his art as soon as he becomes convinced that it will tend to facilitate and improve his labor and render the fruits of it more perfect. It is such contracted views as these which retard the progress and perfection of the noble science of Agriculture, and debase it below the level of the meanest art.

Harrows.

Harrows constitute a second class of instruments which are indispensably necessary in the tillage of arable land; and without which the plow would cultivate the soil but very imperfectly.

These instruments are also made of various sizes and forms, as, of course, they must be, in order to enable them to fulfil all the different purposes for which they are intended. They are divided into two classes; the *heavy* harrows, or those which are drawn by two, four or six horses and the *light* harrows, of which a single horse can draw one if not two.

The large harrows are composed of strong bars of wood, connected together by cross bars morticed into them, and armed with long iron teeth or prongs, each of which weighs one or more pounds. This class is chiefly used for the purpose of breaking the furrow slices of a turfy soil that has been turned over by plowing, or for the purpose of breaking and dividing the clods on tenacious soils; they are quadrangular or triangular in form. In the latter case, these teeth or tines are sometimes shorter toward the foremost angle of the harrow, or that to which the draught power is attached, and increase in size at each row, so that the hindermost row contains the largest. Handles are occasionally added to the hinder part of the harrow, by means of which it can be raised up or forced deeper into the soil; the teeth are either perpendicular, or inclined with the front forward, or curved forward like a bill-hook.

The teeth of small harrows are either formed of wood or iron; indeed, there are some in which a tooth of wood and one of iron are placed alternately. Many agriculturists have altogether rejected harrows having wooden teeth as wholly inefficacious; there are, however, circumstances under which the use of them will prove advantageous not only on sandy soils, for which they are peculiarly adapted, but also on heavy land; which, although tolerably well divided, still contains a great number of clods. On such land it is much easier to expedite the motion of wooden harrows than of those of iron, and the suddenness of the stroke tends more to break the clod than the weight of the instrument or the material of which it is formed. Wooden harrows are likewise preferable to iron ones for the purpose of covering small seeds, or of bestowing a slight cultivation on land in which the plants are just shooting up, or for smoothing and equalizing the surface of a soil where it is not necessary that the teeth should penetrate to any depth. There are, however, many persons who make use of wooden harrows for the sake of economy, when iron ones would be far preferable.

In the variously shaped small harrows the teeth or prongs are sometimes fastened in a perpendicular, at others in an inclined, position: where the latter is the case, the instrument may be used either for light and superficial, or for deep and heavy harrowings, as may seem requisite. When the draught power is attached to the instrument in such a manner that when it moves forward the points of the teeth incline toward the front, these will penetrate better into the soil and produce a greater effect; but, when turned in an opposite direction, their action is less sensible, and they often merely glide over the surface of the soil and scarcely disturb it. The teeth or prongs of the harrow are very seldom round, but, in general, of a quadrangular or triangular shape; this latter form is most preferable, because the angle is more acute; they are also occasionally shaped like coulters, with a sharp edge and a broad back.

There are various ways of fixing these teeth or prongs in the harrow; sometimes they are inserted into the balls or beams by being driven in like a nail; and at others they are merely riveted on, or fastened with nuts or screws. In the former case, it is necessary that they should be made of a greater length, in order to allow their being driven in sufficiently far to render their hold firm, and yet a sufficient length remain outside to admit of their being sharpened when the point becomes blunted. But teeth thus inserted are very apt to be lost; the striking of a harrow against a stone will frequently serve to knock one or more out; and they are not unfrequently pulled out by persons who happen to require a bit of iron for a bolt, or for any other purpose. Those teeth which are most firmly attached to the harrow are nailed on to the frame or beam, after having been previously riveted into a bar of iron; those which are shaped like coulters are frequently fastened on with screws, in order that they may be taken off whenever it becomes necessary to sharpen them.

The following are the chief points necessary to be attended to in a large harrow, if we would have it perfectly fulfil all the purposes of tillage for which we intend it:

1. The teeth should be at a sufficient distance from one another to admit of the earth passing between them, and to prevent it from gathering into heaps.

2. They should be so arranged that the furrows which they have to trace in the soil shall be at equal distances from each other.

3. Each tooth or prong should trace its own particular line, and one not fall into, or become confounded with another.

4. The rows of teeth should be as nearly as possible at equal distances from each other, in order that all parts of the instrument may act with equal power. In by far the greater number of harrows the third essential point is overlooked: the teeth are disposed angle-ways, so that those in the third row fall into the lines traced by those in the first row, and those in the fourth into the lines traced by the second row; thus, one portion of the teeth is absolutely useless, for the clods acted upon by the first row are either broken or thrown on one side, and, consequently, are not touched by the other teeth. Another inconvenience also frequently arises from several rows of teeth falling into the same line, too deep a furrow is formed; for example, when land is harrowed after having been sown with very small seeds, the defect just alluded to is very apt to cause the seed to be buried too deeply. This defect might be in some measure remedied by attaching the draught power a little toward the side of the front beam instead of exactly in the centre, so that the body of the harrow, not being in a right angle with the traces, may move in a sloping or diagonal direction. The lines thus drawn will receive a different direction, and be less liable to run into one another; but where this is done, that portion of the soil over which only an angle of the harrow passes will be less perfectly tilled than any of the rest, and it will be necessary to cause the in-

strument to go over it again, whereby the amount of actual labor is increased. This inconvenience is less sensibly felt in circular harrowing, because the instrument is then passed several times over each portion of land. In those districts where the farmers confine themselves to longitudinal harrowing, it is highly requisite that the teeth of the instrument should be so arranged that each may trace its own distinct line; and also that these lines shall be at equal distances from one another.

In some harrows the draught power, instead of being attached to either of the sides, is affixed to the point or angle; such instruments, especially when their teeth are curved forward, have a starting or jumping motion, which contributes greatly to break the clods and divide the soil.—The regulator, by means of which the draught cattle are harnessed, is movable, and therefore favors this jerking motion; but in this case the harrow must necessarily pass more or less over the part which it had traversed before. When these harrows are small but heavy, and provided with strong teeth, they are productive of material benefit to strong heavy soils, especially when driven over these at a brisk trot. The form of a harrow is usually that of a square—the sides of which are sometimes equal, and at others unequal in length; and the draught power may be attached either to the length or to the width: there are frequently five beams in the length, but only three in the width. Some harrows are of a triangular form, and then the draught power is attached to one of the angles.

In those places where the land is plowed in elevated ridges, and where it is only harrowed longitudinally, a large, stiff harrow will not be able to act upon the whole surface of the ridge.—An instrument divided into two parts, which are united to one another by means of rings, hinges, or little chains, so that half inclines on each side of the summit or crown, is therefore used. Where the ridges are all of equal width, two, three, or sometimes four harrows are thus joined together, so that the whole width of the ridge is tilled at once. The draught cattle are attached to these by means of a common spring-tree bar affixed to the middle, and the horses walk in the centre of the ridge, or a horse is harnessed to each extremity of a pole or beam, which is as long as the ridge is wide, and these animals walk in the open furrows on either side; this is by far the most preferable mode of proceeding on damp, wet soils. This pole is affixed to the harrows by means of chains proceeding from it to each of the instruments, which are thus all put in motion at once.—Should the ridges be raised so high above the furrow that the pole just mentioned is in danger of rubbing against the crown of them, an axle, mounted on wheels, and stretching the whole breadth of the ridge, is then made use of; these wheels pass along the open furrows, and ought to be of sufficient hight to keep the pole or axle from coming in contact with the ridge. This is a rather complicated arrangement, but one that is very beneficial, especially where moist, wet land has to be harrowed after the sowing has taken place, as it prevents the cattle from passing over the plowed land and treading it down; it is well known that on soils of this nature the seed seldom springs up in those places which have been trodden down by the feet of cattle.

In those places where several horses are always used in harrowing, these animals are placed in a slanting position, so that it shall only be necessary to lead the first, and all the others shall be forced to follow in the same direction. To effect this, the straps of the bridle of the second horse are attached to the trace-bar of the first, those of the third to the second, and so on. By means of this arrangement it is much easier to keep the horses in the required position.

Harrows ought always to be provided with sledges on which they can be transported to and from the fields. These sledges are also useful for the purpose of conveying the swing-plows to and from the land on which they are to be used. As the harrow is a very important implement, and one that cannot be dispensed with, and as, moreover, it forms a very considerable item in the expenses of an agricultural undertaking, all possible care should be bestowed on it; when not used, these instruments should be kept under cover, and, whether in the farm-yard or in the fields, should never be suffered to lie on the ground, but always raised and propped one against another.

Harrows are sometimes provided with branches or bushes, and for this purpose several frames, consisting of three or more cross-beams without teeth, are kept; this kind of harrow is very efficacious when it is only necessary to level inequalities and break those clods which have escaped the teeth of a common harrow. They are likewise used for the purpose of burying small seeds, as clover, &c. The bushes used for this purpose should be strong and elastic, but not too thick, or placed too close to each other, or they will be apt to form furrows and carry away the seed which they should only bury.

Some persons make use of harrows formed of branches interlaced and woven like basket-work, and speak highly of the efficacy of such instruments.

It is a point of the greatest importance that the operation of harrowing should be properly performed, and at the fitting season; where such is not the case, the inconveniences resulting cannot be compensated by any care or perfection of tillage. The extirpator is the only instrument which can supersede or diminish, to any considerable degree, the use of the harrow.

The operation of harrowing may be divided into the following varieties:

1. *Longitudinal harrowing*, or harrowing in the same direction with the plowing.
2. *Cross harrowing*, or intersecting the ridges and furrows formed by the plow.
3. *Serpentine harrowing*, or turning the harrow alternately from one side of the ridge to the other, and thus making it describe a line somewhat resembling two figures of 8 placed one under the other.
4. *Round harrowing*. As this highly efficacious mode of harrowing is but little known in most countries, I shall enter into a more circumstantial description of it. It can be practiced as well in those places which have been deeply plowed, and where the ridges are high and wide, as it can on those which are plowed as evenly and uniformly as possible. The horses, of which there are usually four or six, are harnessed in the way before described—some to the trace-bar, others to the harrow. The driver takes hold of the front horse on the left, by the bridle, and

makes him walk around him. The other horses must, as may easily be conceived, describe a larger circle the farther they are from the center. When the circle is almost complete, the man proceeds a few steps farther and repeats the same evolution; and so on, until the whole surface has been passed over by the harrow. It may easily be supposed that the horse which is farthest from the driver has the hardest work to perform; and, therefore, the weakest and smallest are always placed in the center, and the largest and strongest on the outside; or else, when they are nearly equal in strength, they are worked alternately, first in one place and then in the other.—The outside horse is generally obliged to proceed at a rapid trot, even when the center one is moving as slowly as possible. When the soil is very heavy, and the outer horses are obliged to work at full trot, in order to divide and loosen it thoroughly, they become very much exhausted; indeed, this operation can only be executed by animals full of strength and vigor. It cannot be denied that this mode of harrowing takes up a great deal of time, because every part of the surface has to be repeatedly passed over; but, on the other hand, it produces an effect which could not be obtained from any other method of conducting the operation. Quick harrowings of this description are usually performed with harrows having wooden teeth, because horses could not support the labor occasioned by heavy instruments. When the land has been completely harrowed in this manner, the instruments are drawn over it lengthwise—the rate of going in this case being also a brisk trot. The driver mounts the first horse in order to make him go more rapidly. This operation is best executed in Mecklenberg; there is not, in fact, any other operation of Agriculture to which so much attention is paid in that country.

It is even more essential that favorable weather, when the ground contains a proper quantity of moisture, should be chosen for the performance of this kind of harrowing, than it would be for plowing. If the land is too moist, the harrowing will be very likely to do more harm than good, and to harden and agglomerate, instead of dividing the soil. It is also of importance that the ground should not be suffered to become too dry and hard before this operation is performed, as it is then impossible to manage it. Even when the most favorable season and the most suitable degree of temperature have been chosen, all other agricultural operations must be suspended while this one is in hand. In the table, therefore, of those team labors which are to be executed in any particular week or month, harrowing must always occupy a principal place.

The Roll.

The *roll* is another exceedingly useful agricultural implement; in fact, it is impossible to dispense with it in any complete system of tillage, let the nature of the soil be what it may. We shall, in the first place, examine the various uses to which this instrument is applied. It is, indeed, essential that this examination should be gone through before treating of the different forms given to the roll, these latter being determined by the purposes for which the instrument is to be used.

The first object usually aimed at in the employment of this instrument, is to break those clods or indurated masses of earth which have resisted the action of the harrow; or, at all events, to bury them in the ground, so that at the next harrowing—which when thus buried they cannot well escape—they must, of necessity, be somewhat diminished in size. It is for this reason that in countries where the soil is very tenacious, and tillage very carefully conducted, it is the custom, even after preparatory plowings, first to harrow, then to pass the roll over the ground, and then to harrow again. In such places, land not treated in this manner would be looked upon as being very badly prepared.

The second object of rolling, is to give a somewhat greater degree of compactness to a soil which is too light and friable, and to unite its component parts. The roll is not employed for this purpose to so great an extent as it might be with advantage; its action, in this case, being highly beneficial, particularly in counteracting the bad effects produced on extremely light soils by the too frequent use of the plow, and likewise in preventing the too rapid evaporation of the moisture contained in the soil. This application of the roll is particularly resorted to on the spongy soils of valleys; in such situations, indeed, it cannot well be dispensed with.

The third use to which the roll is applied, is to press down and make firm the ground about newly-sown seeds, and to cause the latter to adhere better to the soil. Sometimes, when very small seed is to be sown, it is found advantageous to pass the roll over the ground before the seed is sown, so as to level it thoroughly, and facilitate a more equal distribution of the seed than could otherwise take place. Where the ground has been thus leveled, those seeds which happen to fall together, separate from each other; and it is seldom that two are found lying in one spot. The harrow is then passed over the ground; and this operation is followed by repeated rollings, which obliterate the lines drawn by the harrow. The roller may also be employed with advantage on soils which are neither particularly moist nor tenacious, after the harrow has been used to cover the seed. This operation serves to press the earth more closely into con-

tact with the seed, which then germinates and springs up with much greater rapidity. The truth of this will be plainly seen by observing those parts which have escaped the action of the roll; for there the seed does not spring up so quickly as it does where the ground has been well pressed by this instrument. Probably, too, the pressure may, by the greater compactness which it gives to the soil, prevent any rays of light from penetrating, and thus interfering with the process of germination. Another advantage derived from this leveling of the soil by the roll is, that the harvest is greatly facilitated; for it enables the laborers to reap or mow closer to the ground, a point of great importance, especially as regards the pea and bean crops.

The fourth great use of the roll is to cover with mould, or press against or into the ground, the roots of those plants sown in the preceding autumn, which have been detached by the frost. Soils rich in humus, such as those found in valleys, sometimes swell up in the spring to such a degree that the roots of the plants contained in them are forced up. In such cases, if a fall of rain does not speedily occur, the roll affords the only means of restoring them to their proper position.

Lastly, the roll is sometimes employed for the purpose of destroying insects which injure the young plants, and which, particularly during the night, come up to the surface to seek their food. When applied for this last-mentioned purpose, the operation of rolling should always be performed after the close of day.

The roll is moved by means of a frame or carriage, in which the two extremities of its axis are fixed. The roll itself is generally round, but varies greatly, both in length and diameter; and the shorter it is the more powerfully does it act. Increase of length, far from adding to the amount of pressure, actually detracts from it, by causing the weight to be sustained on a greater number of points of the surface at once. The usual length of the cylinder is from six to nine feet; the diameter varies from one to two feet.

Hexagonal and octagonal rolls are also in use. They are much more efficient for the purpose of breaking clods than round ones; because, at each step of their progress, they fall to the ground more suddenly, and move with a less equal motion. But they require greater force of traction than round rolls, which is probably the reason why they are so little used. I consider that they are capable of producing highly advantageous effects on tenacious soils.

With the same view, rolls are sometimes made with grooves or flutings; but if the soil on which they are used is not very dry, these flutings and spaces become filled with mould, and the efficacy of the roll is of course diminished.

The carriage of the roll is made in various forms, none of which appear to me to possess any great advantages over the others; I refrain from giving any description of them, being fully persuaded that all my readers must be acquainted with some one among the number. The only particular which positively demands attention is, that the carriage should be so constructed as to admit of the driver's sitting upon it. That he should do so is desirable: first, because the weight, and consequently the effect of the roll, is thereby increased; and, secondly, because the cattle can then be driven at a brisker pace, provided that the labor does not fatigue them too much. Another advantage attending this arrangement is, that it protects the driver from the annoyance of the dust, to which he would otherwise be exposed. Rolls without frames are likewise made use of, the extremities of the axles of which turn in rings which are attached to the shafts by hooks. When the direction of a roll thus mounted has to be reversed, there is no occasion to turn the instrument itself, but it is only necessary to take the horses off, unfasten the rings for a moment, and re-fasten them again, when the shafts and the horses have been brought round to the proper position. This mode of proceeding obviates all those inconveniences produced by the roll dragging a quantity of earth round with it as it turns; an inconvenience which is not, however, so perceptible when the circle described by the roll in turning is rather large.

Some persons use stone rolls on their fields. There, doubtless, are cases in which such pressure on the ground may prove advantageous; it appears, however, to me, that in most instances, it will be found too powerful, and consequently the use of these very heavy rolls cannot be generally recommended. I have frequently derived advantage from passing a stone roll over a sandy soil soon after its being dug or plowed up, but this is the only trial of the kind I have made.

Spiky or pointed rolls. These rolls are armed with iron points, the intention of which is to effect a more complete division of the clods; and they are still used for this purpose in many agricultural establishments. Rolls of this description can only be used on very dry soils, and when the proper time for harrowing successfully has been suffered to pass. Where the soil is argillaceous, and likewise contains moisture, it sticks to the points, and becomes so firmly amassed between them that the whole instrument is soon covered with it, and the points cease to be productive of any effect. This inconvenience is less to be feared with rolls which are armed with iron hammers instead of points, the hammers being placed at greater distances from each other than the points. These hammers never fail to break the clods with which they come in contact.

English writers have often recommended the use of rolls armed at intervals with sharp circles or rings, for various purposes, and especially for that of forming furrows in the soil, and for several other uses to which I shall have to revert elsewhere.

It is necessary that a favorable period and weather, when the ground is sufficiently dry, should be chosen for rolling, as for harrowing. It is absolutely necessary that the humidity of the soil should not be so great as to cause it to stick to the roll, for when that is the case the operation is likely to prove more injurious than beneficial, not only to tenacious and clayey soils, but also to those which are lighter, inasmuch as it hardens the ground, and forms over it a crust which is impervious to air and atmospheric action. On the other hand, however, it is not right to wait until the clods of tenacious land have, by the evaporation of all their moisture, become so hard as to render the action of the roll on them totally inefficacious.

PLOWING.

In the performance of this operation it is requisite—

1. That the lines traced by the plow should be perfectly straight, and parallel with one another; the furrow-slices all equal, and uniformly turned up, so that they may not overlap each other, or form any inequalities on the surface of the ground. If it be otherwise, that is to say, if the slices are not of equal breadth, the operation becomes more difficult, because at every deviation from the straight line the resistance which the earth opposes to the instrument becomes increased.

2. That the plow advance at a regular and uniform depth, and on a line parallel to the surface of the soil; that is to say, that it do not, as is the case when it is not well guided, sometimes cut thick and at others thin slices.

3. That the plow empty the furrow as completely as possible, so that the earth may not fall in again after the instrument has passed; and that the portion of soil not yet raised, but which has just been divided by the plowshare, may form not an acute but a right angle with the bottom of the furrow on which it borders.

4. That the furrow-slice be turned up at an angle of about 40 degrees, or so as to form with the surface of the ground, or the bottom of the furrow, an angle of from 40 to 50 degrees; which is in most cases the best inclination.

5. That the divided slices be always of the same breadth; and that it be such as is required by the nature of the soil itself, and the purpose of the operation.

6. That they likewise preserve the depth which it is desirable to give them.

7. That the ridges or heaps of earth between the furrows be of a suitable length and breadth, and that their sides be parallel to one another, so that they may not terminate in a point; for such a form tends to increase the labor of plowing considerably by rendering it necessary to turn frequently.

8. That the plows be placed one after another on different parts of the land to be plowed, so that the operation may be executed in the best possible order, and with as little loss of time as possible.

The fulfilment of these essential conditions is secured to a certain extent by taking care that the plow is properly constructed; but it also depends in a great measure on the skill of the plowman, who must not be actually stupid, or quite a novice in the use of the instrument. The accomplishment of all the other operations is essentially dependent on the skill displayed by the plowmen in the execution of theirs. This remark applies particularly to the head plowman, who directs and superintends the operation, it being his duty to see that the furrows are cut with that perfect straightness of which we have already spoken. The selection of the head plowman is not, therefore, a matter of trifling moment, and it is exceedingly important that this man should have a correct eye.

The inspector of the work should look well that all these things are carefully attended to; it is his special duty to determine the length and breadth of the slice according to the object which is to be attained by the plowing; and if entire confidence with regard to this matter cannot be placed in the head plowman, it is

the place of the inspector to mark out the distribution of the banks or ridges. We shall see in the sequel what there is to be observed with respect to certain peculiar forms of the plow.

The width of the sod or furrow-slice must be regulated according to the nature of the soil and the object to be obtained by the plowing. The greater the tenacity of the soil, the narrower should these slices be cut; for when they are too broad, it is impossible to divide and break them properly with the harrow. From a light or sandy soil, on the other hand, wide slices may be cut without any inconvenience, because the harrow always has sufficient power over such land to pulverize it completely.

The greater the depth of the furrows, the less should be their width, both because the plow would otherwise have too much resistance to overcome, and because if the pieces of earth or sods cut out of them are both broad and thick, they cannot be turned over so completely as they ought to be. But when the plowing is merely superficial, there is no objection to the width of the slices being increased. If the object in view is only to bury stubble, or to turn up the turf of land lying fallow, in order to facilitate its decomposition and disintegration, plowing-in wide slices is admissible, and in certain respects, perfectly preferable.

It has already been observed that two or three inches more or less in the breadth of a slice make a great deal of difference in the quantity of work done by a plow. When the object is to divide a tenacious soil very minutely, the most convenient and proper breadth for the slice is six or seven inches; but where the soil is light, an almost equal advantage will be gained by making the slices a foot wide. The length of ground traversed by the plow in plowing a field is inversely as to the breadth of the slices: that is to say, the length traversed when the slice is seven inches wide, is to that passed over when it is twelve inches wide, as 12 to 7÷; so that (supposing the rate of progress, or in other words, the pace at which the cattle move, to be equal in both cases,) twelve hours are spent in plowing a field with furrows seven inches wide; while only seven hours would be required to plow it if the furrows were twelve inches wide.

If the mould-board cannot be turned alternately to the right or left of the plow but is, on the contrary, fixed to the right side of it, the land cannot be plowed perfectly flat and even; but the plowed surface must necessarily be divided into banks or ridges, separated by furrows, and elevated in the middle in proportion to the depth of these furrows. The plowing is said to be *raised* or *flat* according as the ground is turned up in ridges intended to be permanent, or the operation is conducted in such a manner as to keep the surface as equal and uniform as possible.

The surface may be flattened and equalized to a certain extent by plowing from the edges to the middle of those ridges which had previously been plowed from the middle to the edges; that is to say, those ridges in which the first two sods or slices have been thrown one against the other.* If the land be plowed alternately outward and inward to the same depth, the banks or ridges remain tolerably flat; and if it be subsequently plowed across and circularly harrowed, no sensible elevation or depression will remain to destroy the equality of the surface. If, however, we would bestow the best possible tillage on a piece of

* In order to render the subsequent remarks more easy of comprehension, I consider it requisite to give exact definitions of certain technical terms used to designate the various operations and other matters connected with plowing.

To *plow a ridge outward* is to begin the plowing in the middle, so that the first two furrow slices cut by the plow may rest one against the other.

To *plow inward* is precisely the contrary; it consists in beginning at the two sides, so that the slices first divided fall into the trenches by which the ridge is bounded, and the last two falling in opposite directions leave an open space or furrow in the place previously occupied by the crown or summit of the ridge.

A *ridge* or *bank* is a band of earth formed by the junction of two or more plow-lines, and terminated on each side by a trench.

A *hollow* or *gutter* is a single furrow traced by the plow.

The crown of the ridge is its highest part, where two divided slices of earth cut from the furrows have been thrown one against the other.

The shoulder of the ridge is that part of it which abuts on or terminates it toward the trench.

The trench is the hollow space from which the plow has removed that portion of earth which forms the shoulder of the ridge; or in other words, it is the hollow ridge which one ridge forms with another, and serves to drain off the superfluous water.

The furrow is the long hollow space which the plow forms as it separates and turns over the slice, or that space which was occupied by the slice before it was detached and removed.

The furrow-slice or *sod* is that portion of earth which the plow raises from the furrow, and turns over on the side. [*French Trans.*

ground, it will be advisable not to leave the ridges always in the same place, but to change their position by uniting the halves of two different ridges. To effect this, the shoulders of the ridge must be turned over into the furrow, and the slices successively raised supported, one against the other until, on reaching the middle of each of the whole ridges, furrows are formed in those places formerly occupied by the crowns or summits. In this manner, that portion of ground which had been merely covered by the two first furrow slices forming the crown, becomes perfectly tilled and cultivated.

The flat mode of plowing is decidedly preferable in places where portions of land of considerable breadth belong to the same proprietor, and where there are no particular and important reasons for giving the preference to high and narrow ridges. In most cases these advantages outweigh those which are incontestibly attached to the latter description of ridges. The drainage of water, the accomplishment of which is in many places sought to be obtained by means of the furrows which separate the ridges, is always effected much more completely by means of the furrows which are traced on land plowed evenly, and immediately after the seed has been sown; and the more so as these furrows are always traced in the direction most likely to facilitate the drainage of the water, and have an advantage not always possessed by the furrows which separate the ridges from one another. Great numbers of these channels or drainage furrows may be made in places where they are necessary, and they may be altogether let alone where not required. On land which is plowed flat and evenly, the vegetable mould remains equally distributed over the whole surface; whereas, that which is plowed in ridges is deprived of it in some places and overloaded with it in others. The former retain over their whole surface an equal thickness of newly turned earth; they also admit of a more equable distribution of the manure, which on lands plowed in narrow ridges is apt to collect in the furrows. Then, again, the soluble extractive matter of land plowed flat is not carried away as it is down the slope of the ridges into the furrows. But, above all, the seed can be distributed much better and more equally over evenly plowed land; it may, in fact, almost be scattered at random; the harrow also acts more uniformly over the whole surface than it can do over the surface of land plowed in ridges. Circular harrowing, which is so exceedingly efficacious, is almost impracticable on land plowed in ridges; and even cross harrowing is rendered much more difficult by this mode of arranging the surface. Moreover, land plowed flat is much more easily cleared from couch-grass, and all those weeds which multiply by means of their roots; the carriage of the manure and especially of the harvest is facilitated there; and lastly, the reaper, binder, and gleaner, accomplish their work on it with much less difficulty. The corn lies flat upon it after having been separated from the stubble, and does not fall into the furrows and get spoiled by the water lodged there, as is too frequently the case on land which is plowed in narrow ridges. The rake also performs its office with much more ease and promptitude; in fact, it is only on land plowed in this manner that it is possible to use the large rake, an implement of great utility at harvest time.

The advantages just enumerated are so great, that it is only a small number of particular cases, of which we shall presently have to speak, that can warrant the formation of ridges on a flat soil.

The equal distribution of all the elements of fertility over land plowed evenly gives an equal degree of strength and a uniformity of appearance to the whole crop. On such land we do not see the disagreeable spectacle presented by elevated ridges, on the top of which the corn is too rich and is laid; while the sides and the hollows present nothing but impoverished, sickly looking plants, or, what is sill worse, weeds.

The ridges usually formed on land may be divided into three classes:—

1. Ridges or banks of the width of 16, 20, or 30 plow-lines or more.
2. Narrower and less elevated ridges, which are not bounded by deep furrows; these are from 6 to 8 or 12 plow-lines in width.
3. Narrow and considerably elevated ridges, separated from each other by deep furrows; these are from 4 to 6 or 8 furrow-slices broad.

It is necessary to distinguish properly between these different kinds of ridges, in order that what we are about to say with regard to them may be properly understood. Ridges of intermediate widths may doubtless be found, the classifica-

tion of which is, therefore, uncertain; but such are chiefly found only in those places where tillage is ill-conducted, or directed by those persons who act without method or reflection.

Broad ridges, elevated in the center, are often formed by accident and without intention, especially where the property has been divided into long, narrow strips of land. For, since land so divided must have been twice plowed from the middle outward for every time that it was plowed from the edges inward, the earth must necessarily have become heaped up in the middle, and the crown of the ridge thus formed. In places where, as is frequently the case, there have been no ditches between the lands of different proprietors, or where these ditches have been filled up for the sake of gaining additional surface, all the plowmen have avoided throwing the earth to the outside, from fear that if they did so their neighbor might carry off that which was thus placed within his reach. In this manner, ridges of considerable breadths have become elevated in the middle to such a degree, that two men walking in the parallel furrows which bound them will not be able to see each other.

Such ridges or banks are not only found on lands in which there is more to be feared from wet than from drouth, but even on dry and sandy soils. It is usually advisable to form moist land into broad ridges, as it is said that by this means a portion at least of the crop is secured, and good produce obtained from the crown of the ridge, even if that on the side is sickly, or small in quantity. It is thought also, that if the ridges were less elevated, the crop obtained would be next to nothing. It is true that in the greater number of cases this inconvenience might be obviated in another way, and that here the preference should be given to high and narrow ridges. Nevertheless, the use of high and broad ridges is attended with advantages quite peculiar to itself, and if the arc formed by their segment be properly rounded, and the furrows which bound them made of a proper depth, they afford the best and probably the only means of turning to account lands which are parceled out into small portions and intermingled with the property of others.

It must, however, be observed that ridges of this description are frequently met with on dry lands, and in districts where there is little humidity; in such situations, so far from being attended with any advantage, they are calculated to do nothing but mischief in every way. These broad and highly curved ridges are often formed gradually and quite unintentionally, by plowing them from the middle to the edges more frequently than in an opposite direction; in other cases, they owe their formation to an ill-advised imitation. I know, indeed, an instance of a person, who, attributing the heavy crop yielded by a stiff soil thus divided to this method of plowing, thought he should obtain a similar result from a sandy soil in the neighborhood by treating it in a similar manner.

The following are some of the principal inconveniences resulting from broad and very elevated ridges:

1. The best mould, that which has been most completely manured, becomes heaped up in the middle of the ridge, and gradually removed from the sphere of usefulness and activity by the depth at which it is immersed, while the virgin or barren earth is continually being taken from the bottom of the furrows and carried to the sides of the ridge.

2. Although the crown of the ridge is preserved from superfluous moisture, the sides are much more exposed to it. Besides, the water is often enclosed in the trenches, on account of the end ridges or borders being equally as high as the others, and thus preventing that drainage which would otherwise take place there.

3. During long-continued rains the water often overflows as high as the crowns of the ridges, even when there is a free passage for its escape; because, in proportion as the light soil has been heaped up on the crown of the ridge, just in a similar proportion has a quantity of plastic clay been raised from the bottom of the trench and deposited on the sides. Now this clay completely prevents the water collected in the porous soil of the crown of the ridge from draining away. This water can neither make its way into the impervious soil of the lower stratum, nor pass out through the clay on the sides of the ridges. Such are some of the most evident disadvantages of broad, elevated ridges in wet weather.

4. On the other hand, in dry weather, when light showers are so beneficial to the crops, those banks or ridges which are very high, and the sides of which slope abruptly, derive but little advantage from this source, because the water, instead of penetrating the hardened crust which covers the surface of the soil, merely glides over it and flows off into the furrows; and thus it not unfrequently happens that, after such a shower, the quantity of water which flows into the furrows is more than sufficient to fill them, while the crown of the ridge remains almost as dry as it was before.

5. Broad, high ridges prevent the sun from exerting an equal influence over all parts of the sur-

face. This is particularly the case when the ridges run from west to east; for there is then a striking difference between those sides of them which have a northern and those which have a southern aspect. On the northern side the crops are much less luxuriant, and their growth is, likewise, much retarded. The difference in the progress of vegetation on the two sides is sometimes so great that it becomes necessary to reap the corn on the southern side long before that growing on the northern side has reached maturity.

6. When, during the rigor of winter, the snow which covered the crown of the ridges has been blown away by the wind; or when, in the most critical part of the spring season, the sun melts this snow during the day, and the water in the furrows overflows the ridges, and freezes there during the night, the plants on the crown of the ridge are often torn up by the roots and completely destroyed; so that the portion of land from which most was expected yields no crop whatever.

7. If, on the other hand, the temperature is favorable to vegetation, the corn on the crown of the ridges sometimes becomes so luxuriant that it is laid, and yields but a small quantity of grain; while, on the sides of the very same ridges, and especially near the furrows, the plants have a most wretched appearance, and yield but very poor ears from a different cause.

8. The difficulties attendant on the operation of plowing are greatly augmented by these ridges. It is hard to say which is the best period to select for its execution. The crown of the ridge is often quite hard from drouth, while the sides, and still more the shoulders, are so soft as scarcely to be able to support the pressure produced by the feet of the cattle. In such cases, a judicious husbandman will plow the crown of the ridges first, and defer the plowing of the lower part until the soil there shall be sufficiently dry. But it is easy to conceive how much the sowings must be retarded by such a mode of procedure, and how greatly all the difficulties of plowing must be increased.

9. Circular harrowing is absolutely impracticable on these ridges; the advantages resulting from this operation are, therefore, lost to land laid out in this way. It is, likewise, very difficult to spread the seed over them in an equal and uniform manner; and the labor of this operation is rendered much greater, as also is that of the harvest.

10. The apparent advantages accruing from the increase of surface obtained by laying out land in these undulating ridges are more than counterbalanced by the deficiency of produce on a large portion of the surface.

These disadvantages are so palpable that the least reflection would long ago have been sufficient to cause the abandonment of the practice of plowing land in broad, high ridges, at all events wherever the width of the land would admit of its being abolished, had not even the most enlightened agriculturists been deterred by the fear of the losses resulting from the use of ridges of a medium size, when the change is effected too suddenly.

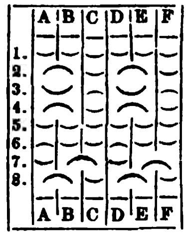
Where these broad and elevated ridges have been only recently formed, the alteration and reduction of them may be commenced without delay. I have known several instances in which this alteration has not only been effected without the slightest loss, but has, on the contrary, immediately led to the production of much finer crops. But when these ridges have existed for a considerable period, and the soil, which is naturally fertile and was heaped on the crown of the ridges, has been for a long time withdrawn from the action of the atmosphere, and pressed down by the feet of the cattle to the bottom of the furrow traced by the plow—then, I say, this soil, although it may contain a sufficient proportion of humus and carbon, is unfit for vegetation, and requires to be gradually called into action by the atmospheric air.

If too great a quantity of this earth be brought to the surface at once, the air does not appear to contain a sufficiency of matters to saturate it thoroughly and restore it to its natural fertility. The vegetable mould, which has been thrown to the bottom of the furrows, is equally liable to be buried at too great a depth; at all events, it does not compensate for the loss experienced at that part of the land formerly occupied by the crown of the ridge.

The ridges ought not, therefore, to be lowered all at once, nor the land turned up and tilled to too great a depth at first; especially if these operations are not to be followed by a complete dead fallow.

A very skillful agriculturist has pointed out the mode of proceeding in the triennial crop-rotation, accompanied by fallows, in order to reduce these broad and elevated ridges in the course of three years. The method which he has adopted with complete success is fully described in "The Annals of the Agriculture of Lower Saxony." Third year.

The following figure will assist us in explaining it:—



The mark ⌒ signifies plowing *outward*, while ⌣ signifies plowing *inward*.

For the Fallow Year.

1. *First plowing.* Plow all the ridges inward.

2. *Second plowing.* Plow the ridges A B together, outward; that is to say, begin the operation by throwing the first two furrow slices into the furrow which separates them, and leave off at their two outer trenches. The ridges D and E are to be similarly treated; C and F are to be again plowed inward, so that they may fill the furrows which separate them from A and B and D E; the trench in the middle of C and F remains.

3. *Third plowing.* This is begun at C and F, which are plowed outward; on the other hand, the large ridges, A B and D E, are plowed inward.

4. *Fourth plowing.*—C and F are plowed inward, while A B and D E are plowed outward and united. Before the grain is sown, the trenches in the middle of C and F are filled up by two light plowings. After the seed has been spread over the ground, the furrows necessary for drainage are made.

For the Spring Corn Year.

5. *First plowing.* All the ridges are plowed inward. This operation must be very superficially performed.

6. *Second plowing.* A and D are plowed outward in the spring; B C and E F plowed inward.

7. *Third plowing*, and that which precedes the sowing; B C and E F are united, while A and D are plowed inward.

For the Third Year. Peas.

8. A is united to B, and C and F are plowed inward.

By means of cross and circular harrowing, the soil will by this time be so completely leveled as to admit of its being plowed across after the crops of peas have been gathered. The last traces of the old ridges will thus be obliterated, and the vegetable soil so well mixed that there will be no reason for apprehending any failure of the crops sown there either during the operation or subsequently to it. Sometimes, after the first plowings, the soil accumulated in the places previously occupied by the furrows, becomes pressed down, and forms hollows here and there; it is, therefore, necessary to pay great attention to the formation of the drainage furrows, so that the stagnation of water may, in all cases, be prevented. If the hollows just spoken of be of considerable dimensions, it will not be difficult to fill them up by throwing earth into them with the plow.

Should the spots formerly occupied by the crowns of the ridges appear too much impoverished, a little manure may be put upon them.

This plan of operations may be modified according to the position of the fields.

Narrow and *slightly raised ridges* are adopted in several countries. As these ridges are only raised in a trifling degree above the furrows, they are not liable to the same objections as those which are much raised; but the number of furrows is increased far beyond what is necessary. Although these trenches are sown as well as the other portions of the land, yet they yield but a very light crop, either because they are less rich in vegetable mould, or because the water which collects in them during wet weather is very injurious and prejudicial to the growth of corn. It is true that the crowns of the ridges yield a heavy crop from the circumstance of the vegetable mould and manure being heaped there; but this does not compensate for the loss on the other parts.

Sometimes the position of the ridges is never changed, but they are plowed alternately inward and outward. As it is in this case difficult to make the plow act upon that slice which remains in the centre and forms the crown of the ridge, that point is often wholly neglected.

In other places, a far better plan of proceeding is adopted, namely, that of al-

tering the arrangement of the ridges so that their crowns may come into the places formerly occupied by the furrows, and these latter be situated where the crowns of the ridges formerly were. Recourse is also had to cross plowing, and then the ridges are not formed until that plowing which immediately precedes the sowings.

Ridges of this description present only two advantages: first, the thickness of the vegetable mould on the space occupied by the ridges is slightly increased; and secondly, the circulation of air between the plants, to which this arrangement of the surface gives rise, tends to diminish that inclination which corn has to droop or be laid when it grows on too rich a soil.

It is very necessary to distinguish between the kind of ridges just spoken of and those which are *narrow*, and at the same time *highly elevated and curved;* such as in some districts are formed by the union of four, six, and sometimes eight plow-lines, and are occasionally so much elevated as to rise to the hight of fifteen and often eighteen inches above the furrows. Ridges of this description are to be met with in Franconia, and some countries south of Germany; in various departments of the south of France; sometimes also in Spain and England; but most of all in Belgium. We find a detailed account of those used in this latter country in Schwertz's work, entitled, "An Introduction to the Knowledge of Belgian Agriculture."*

Opinions are so much divided respecting the utility or inconveniences of this kind of ridges, and the propriety of retaining or rejecting them, that we deem it necessary to give a detailed account of the arguments advanced on both sides; for, however absurd they may appear, they are nevertheless supported by the authority of agriculturists of the highest talent, and by the practice of many eminent men.

In the first place, the advantage derived from these ridges by vegetation is, that the plants are supplied with a thicker layer of earth, which is composed entirely of vegetable matter, light, and strongly impregnated with substances derived from the atmosphere; this layer is collected afresh at each plowing, and, consequently, the plants can easily penetrate it with their roots, both in a vertical and horizontal direction, and derive the requisite amount of nourishment from it. On soils thus arranged, when the ridges are well formed and the furrows traced in such a manner as to enable them to discharge all the water that runs into them, the plants never suffer from excess of moisture, and are equally safe from those injuries resulting from excessive heat; because the light earth heaped up by the plow is capable of retaining moisture for a considerable period. In places where the lower stratum of the soil is impervious, the plants are raised up sufficiently high to remove all fear of their being injured by stagnation of water; so that even in those parts of the field where the furrows are filled with water, for want of proper outlets for drainage, the ridges are often seen covered with very fine, healthy crops. It is said to be a very rare occurrence for plants growing on this kind of ridges to be injured by the winter. The atmosphere exerts its beneficial action upon the soil of such ridges, and especially on their elevated shoulders during the whole period of vegetation; these shoulders are exposed to the fertilizing influence of the sun's rays, and the plants growing on them enjoy all the advantages of light and heat.

Again, as this arrangement of the surface supplies the plants both with light and air, it favors the formation and ripening of the grain in the ear, causes a more prompt evaporation of the water with which the plants are charged during wet weather, and, consequently, lessens the danger of their being laid; it allows of the crops being hoed, and therefore enables us to keep the soil free from weeds. Finally, it cannot be denied that in Belgium, land arranged in this manner always yields very plentiful crops.

Other persons advance serious objections against high, narrow ridges, and affirm that the following inconveniences have resulted from their adoption of them:—

They occasion the loss of a considerable extent of surface, for the furrows yield no produce; thus, one-half, or at least one-third, of the land is barren, or, at all events, yields but a scanty crop.

* Anleitung zur Kenntniss der Belgischen Landwirthschaft.

It is difficult to form these ridges; it takes a great deal of time and a great deal of draught power to plow them outward.

It is no less difficult to plow them inward, or to unmake them; and this operation is often very imperfectly performed. It is not unusual for the last strip of earth to remain unplowed, because the plow has no hold on it, and falls into the furrow.

The sowing of these ridges is likewise difficult; the seed does not get equally distributed, and thus a great deal of it is lost. But the operation which is most imperfectly performed is the harrowing.

If high ridges enjoy the fertilizing advantages arising from the action of the atmosphere, they are likewise more exposed to its influence at periods when that influence is prejudicial to vegetation. Injurious variations of temperature have more effect upon land heaped up in this manner than they have upon a flat surface.

The produce of the crops obtained from high, narrow ridges is, even under the most favorable circumstances, not greater than it would be if the same land were cultivated with care, but on a less troublesome and expensive plan.

The ridges in question render the gathering in of the harvest a much more difficult operation.

The question respecting the advantages and disadvantages of those ridges having been lately received, I think it requisite to state my own opinion on the subject with some degree of precision; acknowledging, at the same time, that I have not hitherto had any opportunity of observing the effects of this arrangement of land, or of making trial of it, and, consequently, do not speak from personal experience.

There is no reason to fear that, by the adoption of these ridges, any part of the vegetable soil will be rendered inactive, especially in places where the stratum of it is not sufficiently thick, since the earth when thus heaped up is no less within the reach of the plants, the roots and suckers of which penetrate sufficiently deep into the loosened earth to enable them to reach all parts of it, and thence to derive a requisite supply of nourishment. In fact, plants are enabled to grow more closely together on these ridges, on account of their roots being able to penetrate deeply into the ground, and having less occasion, therefore, to spread themselves horizontally; consequently, they do not injure those which grow next to them. Above ground, the ears which would otherwise have been too close together have more room to expand. Many persons who have seen land cultivated in this manner assert that there are no empty spaces to be seen between the ears of corn which grow upon it. When the layer of vegetable earth is too thin to admit of the plants penetrating to a sufficient depth, this defect is sensibly diminished by the heaping up of the earth upon the ridges, and, consequently, the plants growing on it acquire greater strength and firmness.

On the other hand, it cannot be denied that, when land is arranged in this manner, the operation of plowing becomes more difficult, and takes up more time. The formation of the ridges on a flat surface; the labor required for changing their position; that of lowering and cutting down the crowns of the old ridges; cartage; the spreading of manure, and particularly the manner of applying it to the surface of the soil, covered merely by the earth which has been taken from the furrow, and to the shoulders of the ridges; the digging up and deepening of the furrows with the spade; the clearing and weeding the ground; the breaking up of the superficial crust; the operation of double plowing, which consists in driving two plows one after the other along the same furrow; the use of the leveling machine; the raking up of weeds; and all those manifold operations described in detail by Schwertz, require great labor, care, and practice: so that, as the author himself observes, the proper execution of all those manipulations is the practical test of the skill and industry of the husbandman. It must be always borne in mind, that these ridges cannot fulfil all the purposes for which they are intended unless every requisite operation is properly and carefully performed; where such is not the case, a very indifferent crop is sure to be the result.

It is for this reason that in places where the agricultural laborers are not very skillful that the crops are nowhere so poor and bad as they are upon land thus arranged; whereas, upon the land of the industrious Belgian, the finest crops are

always those grown on ridges. Hence it would appear that this arrangement of the surface ought not to be practiced, or even recommended, excepting in places where the hand of the proprietor himself, or, at all events, his vigilant eye, superintends every operation; and where, as in Belgium, the laborer has an immediate interest in the success of the crop. It is very evident that this practice is not equally well adapted for large farms in which it is impossible for the proprietor to exercise a strict surveillance over the whole, or for places where proper care and attention in the performance of all the operations of husbandry can only be obtained by the employment of coercive measures, and does not arise from a zeal and an interest in the work itself.

As to the manner of sowing and harrowing these ridges, I confess I am unable to form a distinct idea of it. It seems to me that an immense quantity of seed must be wasted, unless indeed very great pains are taken in the spreading of it. I do not understand how the harrow can penetrate the ground to a sufficient depth to distribute the seed properly and break the clods, without at the same time lowering the ridges and filling up the furrows; I have looked in vain for any explanation of these difficulties in Schwertz's work.* Probably the soil is so well prepared by the preceding operations, that it divides and breaks up of itself.

One of the principal advantages attendant on narrow ridges arises from the facility with which in so populous a country as Belgium they admit of the crops being weeded and cultivated; but in those places where it is altogether impossible to devote the requisite time to the weeding of crops, the weeds increase rapidly on the shoulders of the ridges, and the crops are not so neat and clean as they ought to be. These narrow ridges are peculiarly adapted for the practice of sowing corn in rows, so strongly recommended by Tull; the great agriculturist having directed that the seed should be sown in two or three rows on the crown of the ridge, by means of his sowing machine: while the shoulders are alternately plowed inward and outward, and submitted to the fertilizing influence of the atmosphere.

In order to free the soil of its superabundant moisture, it is only necessary to make a large number of the furrows which separate the ridges; this object can, however, be much better attained by means of furrows, made in the direction best calculated to carry off the water. Where the land is too flat to admit of this

* Generally speaking, the use of narrow ridges has only obtained a footing in those places where the soil is light, and where the plowings are merely superficial. In such situations they make use of a harrow adapted to the form and size of the ridge, or use two harrows of the same kind, which cover two ridges, and are fastened together in such a manner as to act simultaneously without interfering with or impeding one another. I have seen such on the fertile plains of Lodi. In working these harrows the driver walks behind, holding in one hand a whip or a long stick armed with a goad, and in the other a kind of handle attached to the harrow with a small chain, and which enables him without difficulty or inconvenience to direct that lateral motion of the instrument, that shaking produced by the roughness of the ground, which contributes so efficaciously to the breaking of the clods.

In the vicinity of Parma and Modena the lands destined for the production of autumnal corn are all divided into very narrow ridges; notwithstanding they are of an argillaceous nature: but instead of the harrow a kind of leveling machine is there made use of, composed of two cross pieces, and which acts upon two ridges at a time. If the land be covered with large clods, care is previously taken to divide them with mallets. The seed is generally sown in rows, but there would be no sensible disadvantage in sowing it at random, since in clearing out the trenches that portion of seed which had fallen between the ridges might be taken up.

In Bologna and Romagna, where a considerable portion of the land is of a highly argillaceous nature, the fields are divided into elevations of from thirty to forty inches in breadth, slightly curved, and bounded by ditches or drainage furrows, and even the autumnal corn is sown upon them in lines. After having leveled the ground as evenly as possible, the seed is scattered over it at random, and then buried by making small ridges, or rather undulations, about one metre in breadth, but which are not separated from each other by absolute furrows. In order to form these undulations, the plowman sometimes uses the ordinary plow, and then finishes the ridge in two plow courses; but he more frequently makes use of a plow with two mouldboards, which by throwing the earth raised by the share both to the right and to the left, forms in one single course the halves of two ridges, which are afterward completed in the same manner. In order to bury the seed more completely, and level the surface a little, a beam of wood, to which is attached a number of furze bushes or boughs of trees, is dragged over several of these little ridges at once. This operation breaks the principal clods, and throws back a small quantity of mould and seed into the hollow which separates the ridges. But when the soil is very tenacious, this operation does not prevent hollows or small heaps of earth from remaining between the ridges, which retain the water during winter and injure all the plants in their neighborhood. Besides, as the beasts of draught always walk over the place which is to be occupied by the crown of the ridge which they are forming, they bury a portion of the seed with their feet to a very great depth. It is true that this seed is replaced by that which the plow throws on to these places, together with the sod or furrow slice; but, then, the bottom of the ridge is so much the more deprived of it. These disadvantages will be apparent to any one who will cast an attentive glance over the corn crops of these two countries. I, therefore, endeavor to persuade my farmers, both of Bologna and Romagna, to substitute ridges of the breadth of five metres for these undulations, and to separate them by furrows properly cleared. [*French Trans.* 1814.

mode of drainage, raised ridges certainly are useful: but even then their utility is but very imperfect, and only capable of protecting the crops against a very moderate degree of humidity.

I shall not venture to decide whether or not the top of the ridge which is first divested of its covering of snow, does or does not suffer more than an even, uniform surface during the spring, when the ground is alternately frozen and thawed, and during the very cold nights which occur about that time. It appears to me that such must be the case; since in those springs which have presented the greatest variations of temperature, such for example as that of 1804, the top or crests of the wide ridges which in general yield the finest crops were so much injured by the severity of the winter as to yield no crop at all.

In my opinion, it is an incontrovertible fact, that the getting in of the harvest cannot be so easily effected, and requires more hands on land laid out in ridges, than it does on flat fields: the common scythe—that instrument which tends so materially to facilitate the labor, cannot be used here—nor can the large rake: the sickle is chiefly employed in places where the soil is thus laid out, and the corn is placed in bundles, which, on these raised ridges, requires great care, and cannot be done without the aid of a great number of laborers.

With regard to the formation of these ridges, and all the operations thereunto appertaining, I must refer my readers to the classic work of Schwertz, of which I have already spoken, a work which every person who intends to introduce such a system of cultivation on his land ought to be in possession of. I am the more induced to make this reference from the circumstance of not knowing the exact way in which such ridges are formed.

The first consideration to be taken into account when land has thus to be laid out in ridges, is the direction of the inclination most likely to facilitate the drainage of moisture from the furrow, and such a one should be adopted unless there are good reasons for preferring some other. But where this point is quite immaterial, the ridges should be traced from north to south, in order that the grain on each side of them may enjoy nearly equal advantages from the influence of the sun's rays; otherwise, the vegetation of those parts inclining toward the north, will be much more backward than that on those which face the south. Were it not for this, it would be better to plow from east to west, because the soil then receives the rays of the sun more vertically so long as it remains in the state in which it was left by the plow, and profits more by their influence.

On fields situated on mountains, hills, or declivities of any kind, the ridges are usually arranged in a very injudicious manner, viz., in the same direction with the declivity of the soil. Such is, at all events, the case in places where the land is very much divided and the property intermingled, probably because, from the time the division was first made, nobody has been found who would take the superior or upper part of his portion, all the fertilizing juices and particles of which are washed downward, or would resign his share of the lower parts which possess so many decided advantages.

This injudicious arrangement of the ridges is attended with many inconveniences. When heavy rains fall, the vegetable soil is easily washed away by them; and it not unfrequently happens, that at the top of the declivity large hollows are to be found, from which the earth has been washed down to the bottom, where it forms high embankments. When only light showers fall, the water runs too rapidly from the upper part of the field, which is often suffering from drouth, while the lower portions have a plentiful supply of moisture. The cattle employed in plowing are dreadfully exhausted by the up-hill work; those which are naturally indolent and disinclined to exertion, require very severe treatment to make them get through their work; while others, that are active and full of spirit, become heated, and are thus rendered liable to take disease.—Nothing, therefore, but a minute parceling out of the land can justify such an arrangement of the ridges.

The most advantageous disposition of them that can be made on an inclined surface, is to give them a horizontal, or slanting direction. The former is preferable on gentle declivities; the latter on abrupt inclinations. By this means moisture is retained longer in the trenches on hights exposed to drouth, and more humidity is communicated to the superior ridges. Even on rapid declivities, the water flows slowly in those furrows, the obliquity of which diminishes their in-

clination. When heavy rains fall, they do not wash the earth from the bottom of the furrows; and if the showers come but seldom, the land does not suffer so much from dryness. It has sometimes happened that the mere act of changing the direction of the ridges has tended considerably toward the amelioration of property situated on hilly places, increased the amount of produce obtained from it, and rendered the crops less casual.

The arrangement just mentioned is also calculated to lessen the labor of the draught cattle, although it cannot be denied that it increases that of the laborer. When fields situated on a declivity are plowed by a common plow, having an immovable ear which turns the slice alternately upward and downward, it is very difficult to produce a proper revision of the furrow slice when turned from the lower side, because, in that case, it has to describe a larger segment of a circle before it arrives at that point from which its own weight will cause it to fall over. It not unfrequently happens that it falls back into the furrow. The plowman is, therefore, compelled to exert all his strength to keep the plow inclined toward the right, and is frequently obliged to turn over the slice with his foot, unless he is followed by some person whose express duty it is to turn over the slice with his foot, his hand, or with a fork. The best thing which can be made use of in such cases, is that elongation of the mould-board described by Schwertz in his "Agriculture of Belgium."

On rapid declivities it is almost impossible to turn the slice over from below upward. There the only thing to be done is always to turn the slice toward the bottom, until the whole field is transformed into a series of terraces, each one lower than the other. This cannot be effected with a common plow, having an immovable mould-board, except by managing it so that it shall always be engaged in the soil on one side, and shall turn the slice over on the one that immediately preceded it, a mode of proceeding which occupies a great deal of time, and fatigues the cattle very unnecessarily, causing them to pass over every inch of ground twice. It is far better to make use of a plow having a movable mould-board, which can be turned either to the right or left, as seems requisite. Instruments of the description just mentioned are invariably used in all places where they are known. The Mecklenberg binoir is very useful in these circumstances; indeed, in many cases it is superior to the plow, because it does not throw the earth so low as that instrument. It will easily be conceived that by degrees the plow will amass all the good soil at the foot of the declivity, while the top will become barren. Judicious agriculturists remedy this evil by applying all their manure to the upper part of the field, or at any rate, distributing it in such a manner that that part shall always receive the greatest proportion; but this renders the carriage of the manure a much more laborious operation.

When the rapid declivities are plowed in a slanting or inclined direction, it is of the utmost importánce that such an inclination should be given to the ridges as will prevent the plow from having to encounter any sudden or abrupt declivities. Nothing but mere general rules can be laid down for guidance on this point. The first thing a farmer should do before laying out the ridges, is to traverse his land in all directions, and ask himself in different places how the slices can best be turned over. In some places he will find it necessary to plow outward; in others, to plow inward; and in others, again, always to turn the slice over on the same side. The facility with which the work will be performed, as well as the goodness of it, will depend essentially upon the accuracy of the plowman's eye, and his skill and experience in operations of this nature. The binoir will, in general, be found to be preferable to the plow on hilly fields, because in turning over the soil it enables the laborer to exercise his will and judgment with greater freedom. It is a beautiful sight to see the order and regularity with which rapid declivities can be plowed by skillful men, who are accustomed to the use of this instrument.

By means of the arrangement of which we have been speaking, and by giving an oblique direction to the furrows, the water may be made to drain away so gradually as not to carry any portion of earth with it, nor yet deepen the furrows through which it passes.

If it should now be asked, what depth should be given to the plowing, the variety of opinions which exist with regard to this point entangle us in a labyrinth of discussion, through which we vainly endeavor to thread our way. There is

a very great difference between plowing a soil deeply, the vegetable layer of which is not only homogeneous to a considerable depth, but is also equally fertile throughout the whole of that depth, and augmenting a more or less superficial layer of earth by means of deeper plowings, or, in other words, rendering its constituent parts homogeneous to a greater thickness, and impregnating them with fertilizing particles throughout their whole extent.

Every attentive observer must admit the manifest superiority of deep over shallow soils. The depth to which the roots of plants will penetrate when they meet with a fertile soil, varies according to the nature of these plants. There are some, the roots of which have been traced to a depth of fifteen, twenty, and even thirty feet; as, for example, sainfoin and lucerne. Red clover will push its roots to a depth of nearly three feet; and several other plants of common growth probably penetrate even to a greater depth, when, instead of encountering obstacles, they meet with a loose, fertile soil. I have pulled carrots two feet and a half in length, the top-root of which was probably another foot long. But as land is chiefly devoted to the cultivation of various kinds of grain, its value ceases to increase beyond the depth attained by the roots of cereals; at least to a similar extent.

The unassisted eye will frequently enable us to trace the roots of corn to a depth of eight inches; and, with the aid of a magnifying glass, we can distinctly see that these roots have been broken off, and some portion of them still left in the ground. I have myself seen corn grown on the shoulders of ridges, with roots twelve inches long; but I do not think they would have attained this length any where excepting on the shoulders of the ridges, where the influence of the atmosphere is sufficiently powerful to encourage their growth: they would never have penetrated so far on a flat soil, even had it been equally rich. The seed, when sown, is usually placed about two inches below the surface of the soil; consequently, the roots which we can see are six inches long, and it is more than probable that the fine extremities of their fibres extend to a depth of at least twelve inches. Hence it appears that we may consider twelve inches to be the proper average depth for a soil adapted to corn, and admit it as a principle, that the plants penetrate thus far where they find the earth sufficiently loose and friable. Where the plants are sown very closely to each other, their roots are still more disposed to penetrate into the ground. Wherever we have the opportunity of observing, we shall see that the roots avoid each other, and put forth their largest shoots in those places where they will not interfere with others: this is most perceptible in plants growing in water, because we have more opportunity of observing the direction of the roots there. When, therefore, a plant is prevented by those around it from extending its roots in a lateral direction, it pushes them downward, provided that instead of encountering obstacles, it meets with a loose soil well impregnated with nutritive matter. But if, on the contrary, the root encounters a hard or sterile substance, it extends itself on all sides, and, in this case, when the plants are very close together, their roots form a thick and knotty tissue, dispute with each other for room and nutriment, the weakest give way before those which possess more vigor, and, however advanced in their vegetation, are weakened, or latterly perish. The deeper a soil is, the nearer together can plants be made to grow in it without injuring each other, and the greater number of them will attain to perfection. No attentive observer can avoid remarking the wide difference which exists between deep and shallow soils. It appears in proportionate degrees in soils of four, six, eight, or twelve inches in depth; provided that such soils are equally impregnated with humus throughout their whole extent. If it were possible to conceive that each grain of corn bears a plant, we ought to be able to sow land having a layer of vegetable soil eight inches in thickness twice as closely as we could one which had only four inches depth, and obtain a double crop from it. In this manner the value of the soil would be determined by a multiplication of its surface by its depth.

But we must not, however, venture to carry out this principle to its fullest extent, because the influences of the atmosphere always give to extent of surface an advantage over depth: in fact, if we take a cubic foot of earth, and divide it into a space of two square feet, the latter will always bear a greater number of plants than could possibly grow on the former. No impartial observer who has

had any experience in this matter, will, however, venture to dispute the fact that depth of land has a great influence over its value. In order not to exceed the bounds of truth, I shall lay it down as a principle that this value is increased eight per cent. by every additional inch of depth which the soil acquires from six to ten inches, and diminished in equal proportion from six to three inches.

But deep soils have likewise another advantage: they suffer much less from drouth and from moisture than those in which the layer of vegetable earth is more shallow. When the weather is wet, and a great deal of rain falls, the water sinks into a loose soil, impregnated with humus as low as the vegetable layer extends. Such a soil absorbs a quantity of moisture proportionate to its depth before it suffers any to return to the surface. This is the reason why garden ground, which is well tilled with spade labor, never suffers from excess of humidity even when the surface of shallower soils would be drenched with moisture; so long as the water does not ebb back to the surface of the soil, it does little or no harm to the plants. Deep lands retain the moisture which they have absorbed for a considerable period, and communicate it to the surface when that becomes parched and dried up. Nor is this advantage confined to the extent to which the roots of the plants reach; I am well convinced of this from having noticed that during a long period of dry weather, a crop of cereals, growing on land that had some years before been dug up to a depth of three feet, suffered much less than another which grew on a soil only a foot and a half deep, although both these soils had received exactly the same amount of cultivation and preparation.

Nor is this all: crops of grain growing on deep soils suffer much less from sudden changes of temperature, from drouth, or from heat; because their roots, being able to penetrate farther, are less subject to the action of these influences than they would be if nearer to the surface. During excessively hot or very dry weather, it is evident that the plants are much fresher in deep than in shallow soils; in fact, they invariably perish in the latter.

Lastly, it has been every where remarked that corn growing on deep soils is much less liable to be laid even when very luxuriant in vegetation; this is, doubtless, owing to the greater degree of strength which the depth of the roots gives to the lower part of the stalk, a strength which corn growing on shallow soils never can attain, because then the fresh shoots put forth by plants growing closely together cannot find sufficient nutriment to enable them to attain their full vigor. Nor is it to cereals alone that this depth of soil is beneficial; it is not less favorable to the cultivation of plants the roots of which penetrate deeper into the soil, and seek their nourishment beyond the level occupied by the roots of corn. This is the reason why a deeper soil than is absolutely necessary for the cultivation of cereals is always desirable, although the value added by this increase of depth does not increase so rapidly as in the layer which suffices for the roots of corn.*

* "The chemical effect of pulverizing and breaking up a subsoil is certainly advantageous to the plant in two ways, besides others with which we are very likely at present to be unacquainted; first, it renders the soil penetrable to a much greater depth by the roots or minute fibres of the plant, and consequently renders more available any decomposing matters or earthy ingredients which that substratum may contain; and, secondly, it renders the soil much more freely permeable by the atmosphere, rendering in consequence a greatly increased supply not only of oxygen gas to the roots of the plants, but also yielding more moisture not only from the soil, but from the atmospheric air: which moisture, let it be remembered by the cultivator, is in all weathers as incessantly absorbing by the soil as it is universally contained in the atmosphere, abounding most in the latter in the very periods when it is most needed by the plants, that is in the warmest and driest weather.

"It is, perhaps, needless to prove that the roots of commonly cultivated plants will penetrate, under favorable circumstances, a much greater depth into the soil in search of moisture than they can, from the resistance of the case-hardened subsoil, commonly attain. Thus the roots of the wheat plant, in loose, deep soils, have been found to descend to a depth of two or three feet, or even more; and it is evident that, if plants are principally sustained in dry weather by the atmospheric aqueous vapor absorbed by the soil, that that supply of water must be necessarily increased, by enabling the atmospheric vapor and gases, as well as the roots of plants, to attain to a greater depth; for the interior of a well pulverized soil, be it remembered, continues steadily to absorb this essential food of vegetables, even when the surface of the earth is drying in the sun.

"And by facilitating the admission of air to the soil another advantage is obtained, that of increasing its temperature. The earths are naturally bad conductors of heat, especially downward; thus it is well known that at the siege of Gibraltar the red-hot balls employed by the garrison were readily carried from the furnaces to the batteries in wooden barrows, whose bottoms were merely covered with earth. Davy proved the superior rapidity with which a loose, black soil was heated compared with a chalky soil, by placing equal portions of each in the sunshine; the first was heated in an hour from 65° to 88°, while the chalk was only heated to 69° (*Elem. of Agri. Chem.* p. 178). This trial, however, must not be regarded as absolutely conclusive, since the surface of the black soils naturally increases more rapidly in temperature when exposed to the direct rays of the sun than those of a lighter color. A free access of air to all soils also adds to

But if we would have a soil attain all these advantages, and permanently possess them, it is requisite that from time to time it should be plowed to the very bottom of its vegetable layer, turned over, loosened, and every part submitted to the vivifying and beneficial action of the atmosphere. Unless this is done, it will, if merely superficially plowed, generally lose all those advantages of which we have been speaking; a hard crust or *pan* will be formed immediately beneath the sphere of the plow's action, which cuts off the earth beneath it from all communication with the atmosphere and with the layer of vegetable mould. Experience has convinced me that it is not necessary that this deep plowing should take place every year, but only that it should be repeated once in every six or seven years, especially if during the interval the depth of the plowings given to it are varied, for nothing contributes so materially to form the crust of which we have spoken as repeated plowings of equal depth. It appears that the alternate cultivation of cereals and of plants, the tuberculous roots of which penetrate farther than the others, likewise contributes toward the loosening of the inferior layer of the soil, and maintaining its communication with the upper and superior layer.

Land ought, therefore, to be plowed every seven years to the very bottom of its layer of vegetable soil; and the intervening plowings may be more or less superficial, and varied in their depth according to the purpose for which they are bestowed.

It is quite another thing to bring the layer of earth which is beneath the vegetable soil to the surface by means of deep plowings, a layer which, even if it is of a similar nature with the superior stratum, is seldom or never impregnated with the same quantity of humus, and never fertilized by the influences of the atmosphere and the substances contained in it. This unfertile and frequently sterile soil must, in the first place, be ameliorated, impregnated with humus, and saturated by the atmosphere, before we can hope to derive any crop from it.

We have, however, seen cases in which earth thus brought to the surface has, after remaining some time in the air, become exceedingly fertile without the addition of manure. On submitting this earth to various chemical analyses, we ascertained that it contained carbon; but its fertility was speedily exhausted, and if the soil had not been immediately manured, it would, after having borne one or two crops, have become perfectly sterile, and have required repeated ameliorations in order to convert it into vegetable earth.

It not unfrequently happens that when the layer of earth is thus dug up it is productive of very bad effects at first, and is so barren that it can only be sown with those vegetables the top-roots of which seek their nutriment at a great depth below the surface; nor does it acquire fertility until it has been repeatedly manured and exposed for a considerable period to the fertilizing influence of the atmosphere. But this method of improving land which requires so large a quantity of ameliorating substances becomes a very serious undertaking when it has to be extended over any considerable extent of surface; under ordinary circumstances, and unless there are very great facilities for procuring manure from extraneous sources, one field cannot be thus improved without depriving all the others of the portion necessary to maintain their fertility; at any rate, it will be necessary to sacrifice the value of the produce of a great extent of surface, in order to increase that of a small piece of ground. It may be that in many cases the value thus acquired by the soil far exceeds the loss in produce; but very few agriculturists are sufficiently speculative to make such sacrifices.

The practice of deepening the layer of vegetable earth by means of digging or deep plowings, can only be pursued with advantage where the existing system of cultivation tends to produce a larger quantity of manure than can be employed with any degree of profit for the improvement of the actual vegetable soil.

There are many cases in which an agriculturist must be content with a very superficial layer of vegetable earth, and not for a moment think of increasing its depth by digging or by deep plowings. Not to take into account of those places in which the inferior stratum of the land will not admit of its depth being augmented, it frequently happens—

(*a*). That by means of the turf or herbage which has taken possession of the surface of the soil,

their fertility, by promoting the decomposition of the excretory matters of plants, which otherwise would remain for a longer period, to the annoyance of plants of the same species." [*Johnson's Farm. Ency.*

a very thin layer of vegetable earth has been formed, beneath which is an absolutely sterile soil, either of an argillaceous or a sandy nature; and the farmer has only just manure enough to preserve the fertility of this layer of vegetable mould, or perhaps he has not enough, and is obliged to depend on the formation of a new layer of turf for the preservation of its fertility. In such a case, instead of deteriorating from the value of this small quantity of vegetable earth by the addition of a new layer of sterile soil, the best thing which can be done is to keep it as much together as possible, and maintain its fertility by means of the scanty portion of manure which can be allowed to it and by careful tillage. especially if the formation of another layer of turf may be calculated on; for this latter springs almost entirely from the first two inches of the layer of vegetable earth, and the humus contained in the rest has little or nothing to do with it.

(*b*). If the farmer has been endeavoring to amend his land by an addition of marly clay, mould, &c. or by paring and burning (practices which are exceedingly beneficial to superficial soils, although not calculated for deep ones), he must take care not to plow or dig this land too deeply, or to disseminate through too large a space that amelioration which is adapted only to a very thin layer of earth. The depth of soil should never be augmented unless it has been determined that an extra quantity of these ameliorations shall be bestowed, and then the land should be plowed or dug up before they are applied. The same rule is applicable to those cases in which an argillaceous and very tenacious soil is to be ameliorated with lime or calcareous marl, the quantity of which is only sufficient for a certain thickness or depth of vegetable earth.

(*c*). If a sandy soil has always been plowed to the same depth, and a hard crust or *pan* has consequently gradually become formed below the layer of earth submitted to the action of the plow, this crust cannot be broken without doing mischief. If the superior layer of soil has been plentifully ameliorated by good cultivation, this pan which exists underneath it will prevent the moisture, or those fertilizing substances which become detached from the soil, from escaping lower down; and beneath this crust a bed of pure sand will frequently be found to exist. Cases of this nature may occasionally be found united with those appertaining to the former class, for it not unfrequently happens that after land has been marled a similar crust is formed; and, however desirable it may be that this should exist at a greater depth, it cannot be broken or removed farther down without doing harm, and therefore it is better to leave it alone.

(*d*). Lastly, and in almost every case where it is not absolutely necessary that the layer of vegetable earth should be deepened, and where it is likely to produce loss instead of profit.

In by far the greater number of cases in which it is deemed advisable to deepen the layer of vegetable earth, it is best to do it gradually. By the expression "deepening the layer of vegetable soil," we mean the bringing to the surface such a quantity of virgin earth as can be intimately combined with the vegetable soil, and enter into combination with it. By this means the previously existing vegetable layer is not totally buried or rendered inert, and that absorption of substances from the atmosphere which always takes place in newly turned soil becomes more easily effected.

The following are some of the principal considerations which ought to be carefully weighed, prior to the undertaking of the operation of plowing deeply, or increasing the thickness of the layer of vegetable earth.

1. What is to be expected from the earth thus extracted from the inferior stratum of the soil, and has never before been submitted to the action of the plow, taking into consideration its nature and composition?

To resolve this question, the earth must be submitted to a chemical analysis, in order to discover what proportions of clay, sand, lime, or carbon enter into its composition; nor must the stones, both small and large, which it contains be left unnoticed. The best way of practically ascertaining the effect which it is likely to produce on vegetation, is, most undoubtedly, to give it a trial in flower-pots, or on a bed in a garden which is plowed up, and then covered with a layer of this earth.

2. What changes will be produced by the admixture of a certain quantity of this earth with the superior layer of the soil?

Will the defects of the latter be increased, diminished, or corrected by such a mixture? Will this new earth give a greater degree of consistence to loose soil, or will it diminish the tenacity of a clayey one; or, again, will it increase the defects of both or either? What are the proper proportions in which it should be mingled with the vegetable layer, in order to form a soil adapted to the situation of the field and the climate in which it is placed?

3. How far will the quantity of manure which the agriculturist has at his disposal contribute to impregnate and fertilize this new earth to the requisite depth?

Upon these considerations will depend the propriety of performing this operation, and the extent to which it should be carried.

It has not yet been distinctly specified what is to be understood by the terms "deep plowings," "superficial plowings," or "plowings of a moderate depth." In order, therefore, to be able to attach some definite meaning to them, we will suppose a superficial plowing to be only from two to four inches in depth: a moderate plowing, one in which the instrument penetrates from four to seven inches; and a deep plowing, one in which the soil is turned up to from eight to twelve inches below the surface. All plowings deeper than this are designated double or extra plowings; because it is scarcely practicable to turn up land which

has not previously been tilled, beyond the depth of twelve inches with a common plow. I cannot form the least idea of those plowings which are said to be carried to a depth of from eighteen to four and twenty inches.

After what has already been said, it will be evident that in the greater number of cases in which it is desirable to plow the land to a greater depth than has before been attempted, it is best not to add above two inches in depth of virgin earth at a time to the vegetable soil; more than this quantity cannot be properly ameliorated and amalgamated with the upper layer. This operation ought, wherever such a course of proceeding is practicable, to be undertaken at that period which will admit of the layer of newly turned earth being exposed to the atmospheric influences for the longest period of time; that is to say, it ought to be performed just before the beginning of winter. It should also be allowed to continue in contact with the atmosphere during the whole summer, because the fertilizing effects of the air are even more effective during this season than they are in the winter. Such a soil ought to receive a dead fallow, or, at any rate, only to be made to bear those vegetables, the top-roots of which penetrate beyond the new layer of earth, and seek their nutriment in the old vegetable soil; or else, those plants the roots of which lodge themselves below that layer, as is the case with most of those which come under the denomination of fallow or weeded crops. As the new earth thus remains on the surface of the soil, and is constantly moved and loosened, it enters into close contact with the atmosphere, and every particle of it becomes saturated with atmospheric substances.

It is highly important that the chief and most efficacious portions of the manures should be reserved for this new earth; and wherever the arrangements of the undertaking will admit of it, it is desirable that the manure should be conveyed to it and carefully spread over it before the commencement of winter, and suffered to remain on the surface during the whole of the season, because manure which remains on the surface of the soil during the winter is productive of highly ameliorating effects, provided there are no declivities or slopes down which its juices and succulency may be carried away by the rains. Should such, however, exist, the manure may still be carried to the ground and spread over it at the same time; but then, instead of being left on the surface, it should be carefully buried by a superficial plowing. In the succeeding spring the ground should again be slightly plowed and carefully harrowed; the plowing which precedes the sowing must also be very superficial, in order that the new layer of earth may be as little as possible covered by the old vegetable soil.

In this manner I have repeatedly and successfully effected a complete admixture of a new layer of earth with the old vegetable soil, thoroughly ameliorated the whole, and sensibly increased the depth of the vegetable earth, in the course of one single summer; I have obtained an immediate increase of all the crops, and at the close of the rotation have again proceeded to deepen the soil. Many persons have followed a similar course of proceeding, and have never experienced any of those misfortunes or failures which too frequently attend operations of this nature when performed with too much precipitation, at unsuitable periods, or without due consideration of the concomitant circumstances and of the rotation.

Those who propose to deepen the layer of vegetable earth after the manner described in the previous pages, and to carry this operation to a depth of more than twelve inches, will find a common plow incapable of effecting it. They must, therefore, have recourse to double plowing, which is performed either by means of the trenching plow, spoken of in a previous page of this volume, or else by two plows following each other in the same furrow. In the latter case, the first plow cuts and turns over a more or less thick slice; while the second raises another from beneath the place occupied by the first furrow slice, and reverses it on this latter. This operation can be performed by means of common wheel-plows, provided that the second is so arranged as to cause it to penetrate deeper into the soil than the first, and that it has a raised and lengthened mould-board, the higher extremity of which is divergent, and a high wheel on the right side of the wheel carriage. But the operations performed by means of such a plow are very laborious, and require great draught power. The best way of accomplishing it is to make use of one of Small's plows behind, and one of Baily's in front: in this case, three horses will be sufficient to draw the second instrument when the plowing is intended to penetrate to a depth of from twelve to four-

teen inches; but it cannot be denied that the animals will have to work very hard. This operation can be better performed, and in many cases quite as economically, by means of spade labor. Nine or ten men distributed at equal distances from each other may follow the plow; as soon as it has passed, they dig up the ground to the full depth of their spade, and throw the earth which they thus raise on that just turned over by the implement. Nine or ten good able laborers are quite sufficient to keep pace with a plow on soils of a moderately clayey nature; and where plenty of hands are to be obtained, I much prefer this mode of proceeding.*

Pierre Kretschmar, an author who was very highly esteemed in his day, pretended to be able to keep his land in a state of perfect fertility by bringing to the surface a fresh layer of earth alone; because, to use his own words, the layer of earth which is buried enjoys a period of repose, and thus renovates its exhausted powers, while that on the surface is producing crops. He stated in his work entitled "Ooconomische," published at Leipsic in 1749, as well as in several of his other writings, that the necessity of fallows, rotations of crops, and manure, may thus be done away with. The experiments made by him on some land near Berlin, which had been granted to him by Frederick II. were, as may easily be supposed, attended with the most fatal results. Had he immediately set to work to procure manure from Berlin to ameliorate the virgin earth which he continued to bring to the surface, he might, under certain modifications, have continued to obtain crops from his land; but he had not a sufficiently definite idea of the science of Agriculture, and destroyed and ruined his fortune by commencing scheme without carrying out any of them. The interest, however, excited by this man, contributed not a little to direct public attention to the science of Agri-

* M. Von Thaër did not live to witness the great, good effects on some sorts of the subsoil plow of Mr. Smith, of Deanston, and of Sir Edmund Stracey, who has given the results of his experience (*Jour. Roy. Eng. Agri. Soc.* vol. i. p. 256) with a plow he has constructed, and which he calls the "rackheath subsoil-plow."

"On my coming," he remarks, "to reside on my estate at Blackheath, about six years since, I found five hundred acres of heath land, composing two farms (which had been enclosed under an act of Parliament about forty years), without tenants; the gorse, heather, and fern shooting up in all parts. In short, the land was in such a condition, that the crops returned not the seed sown. The soil was a loose, loamy soil, and had been broken up by the plow to a depth not exceeding *four inches*, beneath which was a substratum (provincially called an iron pan), so hard, that with difficulty could a pickax be made to enter in many places; and my bailiff, who had looked after the land for thirty-five years, told me that the lands were not worth cultivation—that all the neighboring farmers said the same thing—and that there was but one thing to be done, viz., to plant with fir and forest trees; but to this I paid but little attention, as I had the year preceding allotted some parcels of ground, taken out of the adjoining lands, to some cottages; to each cottage about one-third of an acre. The crops on all these allotments looked fine, healthy, and good; producing excellent wheat, carrots, peas, cabbages, potatoes, and other vegetables in abundance. The question then was, how was this done? On the outside of the cottage allotments all was barren. It could not be by the manure that had been laid on, for the cottagers had none but that which they had scraped from the roads. The magic of all this I could ascribe to nothing else but the spade; they had broken up the land eighteen inches deep. As to digging up five hundred acres with the spade, to the depth of eighteen inches, at an expense of £6 an acre, I would not attempt it. I accordingly considered that a plow might be constructed so as to loosen the soil to the depth of eighteen inches, keeping the best soil to the depth of four inches, and near the surface, thus admitting air and moisture to the roots of the plants, and enabling them to extend their spongioles in search of food, for air, moisture, and extent of pasture, are as necessary to the thriving and increase of vegetables as of animals. In this attempt I succeeded, as the result will show. I have now broken up all these five hundred acres, eighteen inches deep. The process was by sending a common plow, drawn by two horses, to precede, which turned over the ground to the depth of four inches; my subsoil-plow immediately followed in the furrow made, drawn by four horses, stirring and breaking the soil twelve or fourteen inches deeper, but nothing turning it over. Sometimes the the iron pan was so hard, that the horses were set fast, and it became necessary to use the pickax to release them before they could proceed. After the first year, the land produced double the former crops, many of the carrots being sixteen inches in length, and of a proportionate thickness. This amendment could have arisen solely from the deep plowing. Manure I had scarcely any, the land not producing then stover sufficient to keep any stock worth mentioning, and it was not possible to procure sufficient quantity from the town. The plow tore up by the roots all the old gorse, heather, and fern, so that the land lost all the distinctive character of heath land the first year after the deep plowing, which it had retained, notwithstanding the plowing with the common plows, for thirty-five years. Immediately after this subsoil-plowing the crop of wheat was strong and long in the straw, and the grain close-bosomed and heavy, weighing full sixty-four pounds to the bushel. The quantity, as might be expected, not large (about twenty-six bushels to the acre), but great in comparison to what it produced before. The millers were desirous of purchasing it, and could scarcely believe it was grown upon the heath land, as in former years my bailiff could with difficulty get a miller to look at his sample. Let this be borne in mind, that this land then had no manure for years, was run out, and could only have been ameliorated by the admission of air and moisture by the deep plowing."

Sub-Turf Plow.—"Being on the subject of the subsoil-plow," says Sir Edmond Stracey, "I may as well tell you I have contrived another plow, from the use of which the greatest benefit has been derived by my park land. I call this my 'sub-turf plow.' It is used to loosen the turf about ten inches and a half deep below the surface, without turning over the flag. There are no marks left by which it can be known that the land has been so plowed, except from the straight lines of the coulter, about fourteen inches from each other. In about three months these lines are totally gone; the additional quantity of aftermath, and its thickness, produced from the grass thus treated, have been the subject of admiration of all my neighbors."

culture, and to induce men of talent to make experiments and engage in researches on this subject.

There is likewise a method of loosening the soil to a considerable depth without turning it over, or, in other words, without bringing the substratum to the surface, and one that is practiced with great success on loose soils; this operation is effected by means of a plow without a mould-board, and having only a strong, low, convex share. This instrument passes along the furrow as a common plow, stirs up the earth to the bottom, and thoroughly breaks and divides it. The excellent manner in which this operation is performed is probably hardly surpassed in those countries where the soil is plowed to a depth of sixteen inches with common plows.

In my opinion plowings should never be carried beyond that depth which we term moderate, unless they are intended to prepare the soil for the reception of weeded or leguminous crops. A very superficial plowing will in general suffice for grain, or the land may merely be tilled with those instruments which tend to accelerate and facilitate labor; because when a soil has once been thoroughly loosened and pulverized to the bottom it retains its porousness and permeability for many years, especially if composed of one-half sand and thoroughly impregnated with humus.

In order to to be able to form any correct idea of the number of plowings which it is necessary to bestow on land, we must consider each of the principal rotations separately.

In most of our alternate rotations the soil is tilled before the commencement of winter to its utmost depth, or, at any rate, as deeply as the plow can conveniently be made to go. Where this depth exceeds twelve inches, recourse must be had to double plowings. The second tillage is superficial, it being merely intended to bury the dung; and the third, or that which precedes the sowing, penetrates a little farther. The land is tilled to a still greater depth by means of the horse-hoe, while heaping up the earth round the plants of weeded crops, which, in order to facilitate this operation, are sown in rows. After the crop, a skimming or paring plow is passed over the ground, and also a harrow if requisite, in order to smooth it; and then, before winter comes on, it is plowed slightly. It is seldom that an actual plowing is given to land thus tilled in the spring; such an one would be both superfluous and injurious to land containing fifty parts in a hundred or more, and which has been properly prepared for the fallow crops, especially if the season proves dry. All that is requisite to be done is thoroughly to loosen the surface of the soil to a depth of two or three inches by means of an extirpator, to harrow it, to sow the grain, (which is usually barley,) to bury it with a small extirpator, and then to harrow the soil afresh; or, if the land is to be sown with clover, to scatter the seed, and then pass the roller over it. After bearing a crop of barley, the land is suffered to grow clover only for a year or two. The preparation for the autumnal corn consists in one plowing of a moderate depth; but the skimming plow is likewise passed over the soil. This plowing is performed at least a month before the period of sowing, in order that the soil may have time to sink down again, which is necessary to the success of the crop. The autumnal corn is sown without farther preparation. Some agriculturists make use of the small extirpator to bury the seed, and subsequently pass a harrow over the land. In the following spring, when vegetation recommences, this harrowing is repeated when time or weather will admit of it; and in order that this latter one may be more efficacious, it is seldom that the autumnal harrowing is carried so far as to cause it to break all the clods; it is deemed better that they should remain until the spring, in order that, by then breaking them, the harrowing which takes place at that season may supply the plants with new earth.

If the autumnal corn is to be succeeded by a green crop, one or two plowings are given to the land, according to the nature of the soil and the state of the temperature. Land is prepared for vetches (which are to be mown while green) by two or three plowings. After the leguminous crop has been gathered in, a moderately deep plowing is given with as little delay as possible. Shortly afterward the land is harrowed; and before St. Michael's day the seed is placed in the ground, buried with a small extirpator, and subsequently harrowed.

If the farmer wishes to obtain a crop of oats after his autumnal corn, he be-

stows a slight tillage on the soil in the autumn, and in the following spring plows it to a moderate depth, sows it with oats, and buries the seed by the action of a small extirpator, succeeded by a harrow. This crop is sown about the middle of May, when the seeds of those weeds contained in the soil have germinated and begun to vegetate. Such are the plowings usually given to land cultivated according to the system termed "alternate rotations," where no second crops are required from it.

In those systems of cultivation which require a dead fallow, the chief attention must be directed to that point; for as a whole year is sacrificed in order to devote to the soil the requisite amount of tillage, it would be unpardonable not to render this tillage as perfect as possible, and to endeavor to attain the purpose and intention of the fallow to its fullest extent.

A fallow ought to be productive of the following advantages:

1. A suitable increase in the depth of the layer of vegetable earth by means of deep plowings. 2. The reversion of the earth. 3. Its pulverization. 4. Its due admixture. 5. Its exposure to the influences of the atmosphere; and 6, and what is most important, the destruction of all the weeds contained in it. If, by means of a fallow, all these advantages can be obtained, the benefits arising from it will be sensibly felt through a long series of years.

In the system of cultivation which is associated with the triennial rotation, a fallow plowed three times is a very common, and, at the same time, a very imperfect thing. It rarely, if ever, attains the object in view. In general, the want of a sufficient pasturage for the cattle prevents the field from being broken up until the end of June. Thus, the soil only receives half a year of repose and pasturage, and half a fallow.

In those fallows which are accompanied by four plowings, the first of these is usually given in the autumn, or before the commencement of winter; but sometimes it is postponed until the spring, which is very injudicious.

Fallows are rarely plowed five, six, or seven times, except on the very best soils, and among agriculturists who know how to estimate their soil and to appreciate the value of this careful tillage, or who are of a sufficiently speculative disposition to induce them to sacrifice the produce of their fields during one year, for the purpose of increasing their fertility. Such a system of cultivation would, undoubtedly, be both practicable and beneficial in our climate.

The first plowing is called the "fallow-plowing;" and this operation is designated by the terms "breaking up," or "fallowing" land (*brachfurche*), especially when it relates to the tillage of land that has borne grass, or been mere pasture ground. If the soil to be tilled has previously been corn land, the term *sturzen*, (to fallow) is then made use of; but this is applicable to all first plowings.

The second plowing is termed "re-delving" (*wandefahne*); when it is being performed, they say that they "re-delve," or turn the fallow over. This expression is adopted in some countries, because, during this operation, the slice reversed by the first plowing actually is turned over a second time.

The third plowing is designated by the appellation of "stirring up" (*ruhrfarhee*), because, in fact, it consists in stirring up the soil and bringing to the surface all those portions which had not previously been brought into contact with the atmosphere. If this plowing is repeated, it is said that the soil is "stirred" again. The last plowing is called the "seed-time plowing" (*saatfahre*).

The Romans distinguished these different plowings from one another by certain terms. They called the first "*praescindere*;" the second, "*vertere*;" the third, "*fringere*;" the fourth, "*offringer*;" the fifth, "*refringere*;" and the sixth, or the one preceding the sowings, "*liraro*." Every nation, and almost every province, has its own peculiar denominations for these plowings; and it is necessary to become perfectly acquainted with them, if we could acquire any information with regard to the Agriculture of the country.

When repeated plowings are given to land as preparations for spring and autumnal corn sown consecutively, each of these is frequently characterized by some peculiar term.*

Almost all scientific men are of the opinion that the fallowing or first plowing ought to be very superficial. Formerly, however, in the system of cultivation

* We have here left out several technical terms which are peculiar to the German language. The author designates oats sown after repeated plowings, by the term *Felghafer*; those sown subsequently to another crop of cereals and with the preparation of one plowing only, as *Hartlandhafer*; and those sown on grass or broken-up pasture land, by that of *Druschhafer*. [*French Trans.*

any inequalities still exist on the surface of the soil, a harrow may be passed lightly over it, after it has been suffered to remain for a while in the state to which it was reduced by the plow; this must be done in order to prevent the seed from falling into deep holes, or from being amassed too thickly in rows, which always injures the crop. It is seldom, however, that this occurs excepting on land carelessly plowed. The seed is buried by means of cross-harrowing, or, where it can be managed, of round harrowing. There are various contradictory opinions existent respecting the propriety of using the extirpator rather than the binoir, to give the ground its last tillage preparatory to sowing the seeds. It appears to me that the latter instrument is by far the most preferable, because where it is made use of there is less danger of the seed becoming accumulated in the furrows: but then some means must be taken to prevent the cattle from walking on the plowed land.

When the second plowing has been performed during favorable weather, and carried to a proper depth, all the succeeding tillages may be effected by means of the extirpator; the operations can be much more quickly performed with this instrument, and it is decidedly superior to the plow on all soils of a loose nature. The promptitude with which the tillage can be effected by it enables the farmer to select the most favorable period for the performance of each operation; it breaks the clods, too, much more completely, and thus enables the seeds contained in them to vegetate sooner and be destroyed with less difficulty. Unfortunately, this instrument cannot be made use of for the purpose of burying common stable manure: where this has to be done, recourse must, therefore, be had to the plow; but if the manure merely consists of a thoroughly decomposed compost mixture, or of lime, the extirpator will be found peculiarly serviceable.

There doubtless are many countries in which the farmers have not the least idea of the necessity of bestowing this amount of labor and attention on a fallow. The being compelled to reserve some pasturage for the cattle during half the summer, however poor and scanty it may be, obliges, or at any rate inclines, many agriculturists not to break up the ground for the purpose of fallowing it until toward the end of June, and to continue this tillage in July; then there is not a moment to be lost if we would plow it three times without deferring the sowing, the more especially as this is the period at which the manure is carried. These three plowings may be sufficient to loosen and divide sandy soils, and render them thoroughly homogeneous; in fact, it is not improbable that too great a degree of tillage bestowed on them would tend to injure rather than benefit the ensuing crops, by depriving the land of its adherence and consistency. But three plowings are far from being sufficient to eradicate all the weeds, consequently, in such places the soil is overrun to a dreadful extent with every description of weed, and especially with couch-grass: this is accounted for by the plowings being so near together as not to allow time for the seeds contained in the clods to germinate. Besides, the manure cannot be sufficiently divided and mixed up with the soil to enable the first crop to derive those advantages from it which might otherwise be obtained. It not unfrequently happens that on fallowing land which has been thus tilled, lumps of dung are found similar in appearance to peat, and which can with difficulty be broken. It is on land thus cultivated that it may with truth be asserted, manure produces less effect on the first than on the second crop. For the sake of a scanty pasturage the farmers forego all those advantages which might be attained by the sacrifice of the produce of their land for one whole year. Necessity may be pleaded as an excuse for this error, but whence arises that necessity?

The usual preparation for spring corn is three plowings; and in order to have time to give these, the land is broken up in the autumn after the sowings of the season are completed. It is seldom, however, that the ground is broken up immediately after the harvest, even in agricultural undertakings where this is practicable: the old proverb "Let the plow follow the sickle," ought to be attended to oftener than it is. But whenever this is done, the land may be plowed a second time before winter comes on,* otherwise that operation must be performed

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This ought to be the preparation for the spring sowing, but it not unfrequently happens that weather or want of hands prevent the farmer from giving it, and he is forced to content himself with two plowings, the first of which is very imperfect. Oats and large two-rowed barley are frequently sown with this scanty amount of tillage, because the farmer fears that if he stops to give more they will not be got into the ground soon enough. Small spring barley, in four rows, need not be sown so early, and it is probable that it is on this account that it is preferred in those places where the triennial rotation is in full vigor; in fact, in this rotation it is so necessary that three plowings should be bestowed on land intended for the reception of barley, that the farmer must not be deterred from giving them, by any fear of the evil consequences which may result from such a late sowing. The tillage bestowed on land in the spring as a preparation for barley, frequently contributes far more to loosen the soil than one plowing at the end of autumn given to land which is to be fallowed in the ensuing year, especially if the spring is drier than the latter end of autumn was.

The practice of *half plowing* is frequently had recourse to for the purpose of fallowing land. This operation consists in raising slices of earth with the plow, which are turned over strips of untouched ground, which latter alternate with the furrows emptied by the plow throughout the whole of the field, and are covered by the furrow slice: but the slices must be rather wider than the strips of earth if we would have the latter entirely covered by them. This practice facilitates the decomposition of stubble, the action of frost on the ground, and the loosening of the earth; it enables the harrow to act more efficiently on the following spring, to tear up the couch-grass and other weeds, and to divide the soil more completely. But this operation must not be delayed too long, otherwise, on land thus tilled, the slice which covers the strip will have entered into vegetation with it, and there will be great difficulty in leveling the soil. This mode of plowing prevents the land from suffering from excess of humidity, because the water runs into the furrows left open by the plow and leaves the slices dry. Sometimes after the harrowing the operation of half plowing is repeated; but on this occasion the order is reversed, the strips are transformed into furrows, and the slices raised thence are inverted on the places previously occupied by the furrows.

But whenever it is practicable to plow the land across, that will be even more beneficial than a second *half plowing*.

The operations of plowing require constant attention from the farmer, or from the person who has the management of the undertaking; they must, in a manner of speaking, never be lost sight of, even though not always able to be present. If he has several plows at work, he ought to put each one under the guidance of some laborer, and on no account to forbear testifying his displeasure if he finds the slices carelessly turned over, or the furrows crooked or uneven; should he fail to do this, the same spirit of negligence will soon pervade every portion of this operation.

The first plowing requires the greatest attention; every possible care must be taken to make the slices of equal width and depth throughout. Next to this operation, the one which precedes the sowings requires most precision; the intermediate plowings are of comparatively but little importance. Should it be necessary to perform several plowings on different parts of the farm at the same time, the most skillful laborers must always be picked out for those just mentioned.

Both the eye and hand of the master should invariably be put in requisition to see that all the plows are in proper working order, even though the care of all the agricultural implements may be the province of the inspector of the in-door operations, or the overseer or head laborer.

In order to make sure that the laborers shall execute that quantum of work which they ought to do and are able to perform in a given time, it is desirable that large extents of ground should be divided into portions by driving in stakes, or by parceling out the soil into a certain number of beds; such a division will

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In order to make sure that the laborers shall execute that quantum of work which they ought to do and are able to perform in a given time, it is desirable that large extents of ground should be divided into portions by driving in stakes, or by parceling out the soil into a certain number of beds; such a division will

also be found useful for distributing the manure, the seed, and various other operations.

In large agricultural undertakings is it advisable to employ several plows on one bed, or to divide them among the different ridges? There are many farmers who make use of ten or twelve plows one after another, and thus plow tolerably large beds of land in but few plow-lines; this plan is adopted in order to render the task of overlooking the laborers one of less difficulty, and to enable one bailiff or overseer to direct the operation of all the instruments at once, and superintend the plowing. Others either only put one plow on each ridge, or at most not more than two or three: this is my practice. The latter appears to be the best mode of proceeding, when we come to consider that if several plows are at work one after another they will all be stopped by the slightest disarrangement of the foremost one. Besides, while thus working after each other one will cover the faults of another, so as to render it impossible to discover which of the laborers work well, and which badly; the master or overseer is consequently unable to appreciate the degree of skill manifested by each of his men. It is impossible to make teams and laborers work together whose activity, strength, and skill are not equal. Lastly, unless the beds are left unfinished, almost all the plows are obliged to stand still while one or two of them are finishing the operation.

It is easy to distribute several plows over the same field, and yet allow them to be sufficiently near together to admit of all being under the surveillance of one person, without putting them on the same bed or ridge; all that is requisite to be done is carefully to mark out the ridges, and to allot to each plow its own.

The borders or mounds of earth at the extremity of the ridges, and on which the team turns in order to commence a fresh furrow, require particular attention and examination, because the pressure of the feet of the cattle on those parts hardens the earth excessively. If the land is plowed outward, in order to form a ridge, they frequently oppose a high bank to the drainage of water; if the ground is plowed inward the water collects in the middle furrow; it is better, therefore, to give them only one inclination, or, in other words, to turn over all the slices on the same side.

Plowing can only be productive of all the advantages which it is capable of producing when the ground is in a proper state to benefit by that operation; that is to say, when it is sufficiently dry and friable, and inclined to divide. When the soil is moist, so much so that the slices adhere together, and the friction of the plow forms a shining crust, which when dry becomes extremely hard, it divides into lumps harder even than the soil was before it took place; and these lumps part again into clods of various sizes, which it is almost impossible to break until they have been acted upon and restored to their primitive permeability by the action of the atmosphere and of frost. It may easily be supposed that such a plowing neither destroys the weeds themselves nor such of their seeds as are contained in the soil; the couch-grass is only multiplied by being cut: besides, the labor of this operation, which is in itself so useless, is very fatiguing to the draught cattle. On the other hand, the plowing is equally laborious, both to the laborers and to the cattle, when the ground is too dry, especially if badly constructed wheel-plows are used; the soil does not in this case divide equally, but splits into clods. Nevertheless, with the help of good implements, and with an accession of draught power, the operation can be performed under these circumstances; and the only inconvenience attendant on the plowing of dry soils is the expenditure of time and labor; for the clods just spoken of fall to pieces as soon as ever a heavy rain comes on, and form a very permeable and friable soil. In all cases it is of the greatest possible importance that the period at which the soil possesses that degree of humidity which is most favorable to the operation should be chosen for the plowing of stiff clays. And as this favorable degree of moisture does not pervade whole farms or even whole fields at the same time, it requires constant and vigilant attention on the part of the farmer to enable him to seize on the exact moment which is propitious to each particular spot.

It is by his attention to these minutiæ that the scientific is distinguished from the merely practical agriculturist; and this circumstance alone will frequently render the crops of the former far superior to those of the latter. The places which are most difficult to be plowed ought to be taken at the most favorable

period, and all the manual and draught power which the farmer has at his disposal brought into play for the purpose; it is often of the utmost importance that not a single day should be lost.

The English [in some counties—Ed.] designate that state of the soil in which it is exactly fit to be plowed, by the word *tid*. They say "the soil has now the *tid*," or "the land was plowed or sown at good *tid*." Our laborers say "the soil is now *gaare*," or it has been plowed or sown at the most favorable period. The French say, "the soil is now *de prise*," or "it has been plowed" *en bon temps*.

It is necessary to select the moment for harrowing with even more care than that for plowing; the state of the soil will always determine the expediency of performing the harrowing at once, or deferring it to some future period. It is, doubtless, exceedingly desirable that the soil should be left for a certain period in the state to which it was reduced by the action of the plow, because it is then brought into closer contact with the atmosphere, and a great portion of the weeds contained in it, as well as their roots, withered and dried up; in general, therefore, it is better not to harrow the soil immediately after the plowing. I should not, however, advise any one to postpone the harrowing until a few days before the ensuing plowing, because in that case those seeds of weeds contained in the soil have not time to germinate; besides the roots of the weeds cannot then be so easily separated from their hold in the soil and pulled up. Hence it will appear that the best period for harrowing is, as nearly as possible, the middle of that space of time which intervenes between one plowing and another; but this must not be thought to be applicable to every kind of soil indiscriminately, and can only be considered as a general rule when applied to such as do not resist the action of the harrow when they have got rid of their superabundant moisture.

Tenacious soils which become harder the more they are impregnated with water, require that the exact moment when they can be divided with least difficulty should be embraced for harrowing them; it is dangerous to allow this to pass by, especially if the temperature seems settled; thus it is often advisable to harrow land on the same day on which it is plowed. It is on this account that in some countries, the soil of which is of an argillaceous nature, it is customary to attach a third horse to the trace of the right-hand horse attached to the plow, which animal draws a little harrow, and thus divides the soil immediately after the plow has passed over it. Young horses which require training, or weak animals, are employed in this work.

CLEARING LAND.

It is seldom that uncultivated land can be plowed until after it has been cleared; nevertheless, we have permitted our instructions with respect to the former to precede those relating to the latter, because they constitute an introduction to what we shall now have to say; and, besides, a farmer always plows the arable land he has already, before he attempts to clear and take in fresh portions.

In order not to separate the various portions of this subject, we must here enter into an examination not only of the manner in which the operation of clearing should be conducted, but also of those financial considerations which must not be lost sight of in such an undertaking.

That the chief part of waste land might be turned to advantage, is a question which admits of no doubt whatever. Land covered with furze; the soil of ancient forests overrun with this plant, or covered by stagnant water; those moving sands which are often carried from place to place by the wind, and threaten destruction to the neighboring country; neglected tracts which yield nothing at all, or at most but a scanty return; in short, almost all kinds of land are susceptible of some kind of tillage, and capable of yielding certain varieties of produce. But operations of this nature are not always attended with profit; on the contrary, it often happens that land thus brought into cultivation eventually costs as much, if not more, than it would have been necessary to give for the purchase of such as was already in a state of cultivation.

Even when the plan of proceeding in conducting these operations is such as positively to ensure success, the outlay of money which they require, and the time which they occupy, are so considerable, that whoever thinks of undertaking such improvements should, in the first place, carefully consider whether or not

it will be in his power to carry them out, and whether, during their progress, he may not find cause to regret the expenditure of so much labor and capital upon them. Both public and private interest demand that undertakings of this nature should rather be left altogether unattempted than abandoned in the middle or imperfectly executed. It often happens that those sacrifices which have been made for the sake of bringing fresh portions of land into cultivation are not followed by any satisfactory returns, because they have not been carried out to the requisite extent. Indeed, it is by no means uncommon for land thus treated to become even more sterile than it was before. A pasture capable of keeping sheep, or land on which bushes and small trees grew, may by these means be reduced to the condition of a barren waste. Such occurrences frighten and discourage the descendants of those who have engaged in such speculations for several generations, and cause them to blame their ancestors for having deprived the other lands on their estate of that cultivation and manure which would have benefited them so materially, and wasted it in a vain speculation.

When, therefore, such an undertaking is in contemplation, it is of the utmost importance that all the circumstances connected with the locality in which it is to be executed should be carefully examined, and an exact estimate of what may be the value of the land, and how much that may be influenced by position, &c., made. It must also be considered under all the relations pointed out in the treatise on "Agronomy," and in that division which relates to the "Valuation of Estates."

It is also necessary to inquire whether we possess an absolute right of property over the land; whether we can dispose of it by legacy or by sale; or whether, on the other hand, we possess but a limited right in it. All liabilities attached to the soil, or taxes based upon the amount of produce which are likely to intrench so largely on the returns as to exceed the profit arising from the improvement of the soil, and thus annihilate the advantages which might have been expected to accrue, must be taken into account. Tithes too often actually destroy the profits.

It is likewise necessary to be well assured that the requisite number of laborers for carrying on the work can always be procured in the neighborhood, and also that the labor which may be expected from them is proportionate to the wages which they demand; whether it is necessary to provide oneself with the teams which will be required, and maintain them upon purchased fodder, or on the other hand, whether the beasts of draught which must be employed in the operation, can be hired in the neighborhood. Finally, and this perhaps, ought to be the first consideration, whether we shall have at our disposal for a sufficiently long period the amount of capital requisite to cover all the outlay, and whether we can dispense with the interest of it during the whole time that the improvements are in progress.

There are two cases, in particular, which require to be well distinguished. Either the clearing is to be performed in the neighborhood of an agricultural establishment already organized, and carried on in connection with it, so that it may be performed with the same teams, laborers, and resources, and at the most convenient periods; or an entirely new establishment is to be organized upon the very soil submitted to the operation, and the agriculturist has to look to that soil for the means of cultivating and improving it.

In the former case, the difficulties to be encountered are not so great as in the latter. Nevertheless, it is necessary maturely to consider in what manner the land about to be brought into cultivation can best be placed in connection with the existing establishment, and to determine to what extent the old and new portions of soil will be able to assist each other; how they can be blended together so as to form a well-regulated and well-proportioned whole; and, above all things, carefully to inquire whether the nature and situation of the land about to be enclosed will admit of its being subjected to the same rotation as the rest, or whether the system of cultivation employed on it must be different from that of any of the rest of the farm lands.

In effecting such an addition to the land, it is not unusual to fall into one of two extremes.

Sometimes the old land is neglected from a predilection for the new and the entire resources of the estate exclusively devoted to the latter, to the manifest detriment of the whole. The consequence of this is, that the net profit is often

diminished during a long series of years; or, on the other hand, and most frequently, the new land after having been broken up is treated merely as an accessory to that portion previously in a state of cultivation. It is exhausted, deprived of all its nutritive principles and power by being made to bear a series of crops intended for sale or for home consumption, without rendering back to the soil whence they sprang the manure arising from it. This mode of proceeding is based upon the erroneous supposition that the soil naturally contains a sufficient quantity of nutritive matter to enable it to produce a succession of crops; and when this is exhausted, a moderate manuring with dung will restore it to a state of fertility. Experience has, however, clearly proved, that when newly cultivated soils have been thus impoverished, they do not recover their condition until after having been repeatedly manured, and without such treatment actually yield no profit. Under such circumstances, they are usually abandoned in their exhausted state as barren and useless soils, incapable even of affording a scanty sustenance to sheep, and are made use of as scare-crows to frighten other persons and deter them from entering into speculations of a similar nature.

The rule which it is most important to observe, and which can never be transgressed with impunity, is to endeavor to derive a sufficient quantity of substantial fodder from the newly cultivated land to admit of a larger number of cattle being maintained. Unless this land consist of an alluvial soil of great natural fertility, it will be necessary to cause it to bear at least two crops of fodder, or else be laid down to grass during that period; for each crop of corn obtained from it, and the whole of the manure resulting from the consumption of its produce, must be bestowed upon it. If this is not done, an equal extent of the old fields must be laid down to grass, instead of the newly cleared land, and the manure produced by the cattle fed upon such pastures devoted to the improvement of the latter. But under such circumstances, even though the plan thus described may be capable of effecting the fertilization of the newly cleared lands, still, if the earth of which the soil is composed be of a very light and porous nature, it must not be submitted to the action of the plow for several successive years, unless care be taken to alternate the corn crops with crops of clover and other fodder plants; otherwise the land will be deprived of all its consistency. In a word, in the distribution of newly cleared land, we must endeavor to give to the whole of the agricultural establishment that equilibrium and those just proportions which will ensure its success, and avoid all risk of disturbing the harmony of the whole.

The difficulties to be surmounted are much greater when the operation of clearing has to be undertaken in a remote situation, and a new agricultural establishment founded and arranged on the land itself. In such cases, it is perfectly impossible to do without cattle, if we would bestow that quantity of manure on the soil which is indispensable to its fertility; these cattle cannot be maintained without an adequate supply of fodder, and the fodder cannot be raised unless the soil is manured and tilled. These things are naturally dependent upon one another: it is therefore necessary, in the first place, to bring the soil into a productive state; and this is the foundation of the whole undertaking. Consequently, we may consider it as an invariable rule and fundamental principle, that in the first place, a portion only (greater or less according to circumstances) of the land which is to be cleared shall be broken up and brought into cultivation, and then the clearing be gradually extended to the remainder; the first portion must be brought into as good condition as possible, by bestowing upon it all the labor and manure which it requires, in order that it may be able to produce those crops which will serve to supply the subsequently cleared pieces of land with the manure necessary for their fertilization, and thus serve as the basis of the whole undertaking.

If the teams required for the execution of the tillage operations of the first portion of land can be hired in the neighborhood, it will be found more economical to employ them, although paying highly for them, than to keep teams belonging to the establishment; unless, indeed, employment can be found for the latter throughout the whole of the year. If the proprietor should have an agricultural establishment at no very great distance, it will perhaps be most advantageous to send the teams thence to the new estate, during that portion of the year at which they can best be spared.

It is seldom that cattle can be maintained at first, on account of there not be-

ing a sufficient supply of that kind of fodder which they require, and because, if they were purchased under such circumstances, they would eventually cost more than they would repay. Sheep, on the contrary, may almost always be maintained, for no one would think of attempting to cultivate spots so barren as not to be capable even of yielding a scanty sustenance to these animals. Should there not be a sufficient quantity of fodder at first for the maintenance of the sheep during the winter, only such as are intended to be slaughtered must be kept. But the requisite amount of pasturage will soon be obtained if the animals are penned on the land which has been sown with fodder plants, and if only such plants have been sown as are of rapid growth, as spurry, radishes, rape, buckwheat, &c., and the sheep that are fattening are made to eat them while green. After these plants have been gathered or eaten off the ground, the sheep must again be penned on it; and subsequently it may be sown with grain, intermixed with red or white clover, according to the nature of the soil, in order to obtain fodder from it or leave it as pasture land. When a portion of the land to be cleared has thus been brought into a state of cultivation, the clearing may be continued from year to year; and the establishment will soon be in a sufficiently prosperous state to be able to support horned cattle and produce stable manure.

When a soil which has been left for some years in the state of pasture land, after having been previously sown with clover, is broken up, plentiful crops will be obtained from it; and this portion will yield not only corn enough for supplying the establishment with bread, but also the quantity of fodder requisite for the maintenance of the horses; and then is the time to effect a complete and perfect organization of all the several parts of the establishment.

At the commencement of such an undertaking, the first and only point to be attended to, is the means of obtaining fodder, and through it manure. It will, generally speaking, be necessary, for a considerable period, to abandon all idea of obtaining any net profit; indeed, it will rather be desirable to devote a second amount of capital to the tillage of the land which we wish to improve and bring into cultivation, and advance certain sums for that purpose, which, may, however, be gradually diminished every year. This outlay, and the interest which it would have yielded under investment, will be amply repaid by the increase of produce which will eventually be obtained from the soil.*

From what has already been said, it will be evident that the operation of clearing and improving land, when executed upon soils of ordinary fertility, absolutely requires a command of pecuniary resources, united with a great deal of ability, zeal and patience. No person ought, therefore, ever to undertake it who is short of money, or who is not largely gifted with experience and perseverance; although it too often happens that persons who possess least of all these qualifications, are the very men who engage in such speculations. Many agriculturists have been completely ruined by operations of this nature; even when the soil on which they worked was of a very good quality, they have been compelled to abandon the enterprise without bringing it to a favorable conclusion. Under the most favorable circumstances, the soil does not attain any great degree of fertility, if from any cause it has been impossible to bestow the full amount of outlay which it requires, and of tillage upon it; unless, indeed, it is naturally possessed of an almost inexhaustible quantity of nutrition and richness, as is the case with the marshes of the Oder and the Wartha.

At all events, clearing of land is an undertaking not at all adapted to the circumstances and resources of small farmers, or of the peasantry. Even if any one were inclined to assist men of this class in such operations by pecuniary advance, they would be unable to extend their views through a long series of years; they would require to reap the fruits of their labor at once. There is certainly every reasonable ground for expecting a speedy return of capital when the soil to be cleared has been for years old forest or pasture land, supposing that an exhausting system of cultivation is resorted to, and the land by repeated plowings, without any attempt at obtaining the means of maintaining cattle and procuring manure, is made to produce a rapid succession of crops intended for sale. But it must be remembered that such a course of proceeding will soon reduce any soil,

* See the "Annalen des Ackerbaues," 1808, vol. vii. p. 313, in which will be found a detailed account and estimate of a project for clearing an extent of uncultivated ground.

however naturally rich, to a state of absolute sterility; and that when in that state it certainly may be made to keep a few sheep from absolute starvation, but is incapable of nourishing or fattening them. There is no country on which so great an extent of waste land has been brought into cultivation within the last half century, as has been in Scotland and the north of England. In both these countries the clearing has been for the most part successfully performed by societies instituted expressly for the purpose, the members of which actively interested themselves in the matter. These societies purchased an extensive tract of land, and caused it to be cleared under the superintendence of a very able man; then, when it had been prepared for tillage, and, in many cases, not until it was actually brought into a state of complete cultivation, it was sold in separate portions, either with or without the buildings, or else farmed out. But, on the other hand, these clearing operations have never been successful when the land has been parceled out before the clearing was performed; for the petty farmers have then, as in our own country, been invariably ruined.

When some substance adapted for the purpose of manuring the soil is found upon it, as marl, mould, peat, lime, &c., the clearing may be accomplished in much less time. The operation is equally facilitated when irrigated meadows can be formed by stopping the course of small rivers or brooks, or accumulating the waters of springs; when such accessories can be attained, they should always be attended to at once.

The first things to be done are carefully to determine on the manner in which the land about to be cleared can best be turned to account; to lay down a plan of operation which is drawn up with due regard to the nature of the soil and the ends proposed to be derived from it; and to precisely and perseveringly adhere to such a plan when once it is arranged. It is highly important that the improvement of the land should be commenced at that part which is most capable of being converted into meadow or pasture ground, even though it should be determined to submit this land to the plow at some future period; by so doing, a supply of manure will be ensured, and the fertility of those portions of land subsequently cleared will be increased.

It is upon the soil of ancient forests that operations of this nature are usually performed, and it is upon such soils that they are attended with the greatest advantages and success, both as regards the person by whom they are undertaken and society in general. The preservation of old, decayed forests is not at all likely to remedy those evils which are constantly complained of, arising from a scarcity of wood. To remedy this evil it is rather necessary to pull up all sickly and isolated trees, to extirpate bushes, and establish thickly planted and well enclosed forests. There are many countries possessing little forest land in which a scarcity of wood is not more felt than it is in others in which forests and woods occupy a considerable portion of the surface. In many cases it would be advisable and beneficial to enclose and convert into plantations those corn lands which have been well cultivated, but have become exhausted; and thus gradually extirpate and replace the old forests, and convert them into corn lands. The soil of forest land usually contains a sufficient quantity of nutritious matter to enable it to produce both crops of fodder and of corn, even without being manured with dung; and, consequently, will yield an immediate return for the expenses of clearing, without being exhausted by so doing.

It cannot be denied that the extirpation of trees and bushes often requires a great deal of labor, and, therefore, various machines have been invented for the purpose of performing the operation with greater facility. But these contrivances have not as yet exhibited any decided advantages; and it now appears to be a well attested fact, that it is not in the power of mechanical science to invent any machine possessed of sufficient force to uproot large and old trees.

The clearing of wood and forest land is in general performed by task work, the price being regulated either by acres, or by the number of cords or fathoms of wood resulting from the process. In this case, care is taken to stipulate definitely that the ground shall be cleared of roots as thoroughly as possible: very frequently the heads of the trees, or, in other words, the portion of the lower part of the trunk from which the roots grow, or from which the stem is separated, are given as payment for the labor of clearing land.

When the ground is overrun with the roots of black-thorn, brambles, or even

by the stumps of oak, elm, ash, or maple trees, it is very difficult to clear it so completely as to prevent the roots from throwing up new shoots. The trouble of this may be saved if the ground is to be suffered to remain for several years as pasture or meadow land; it will then be sufficient, after having torn up the principal roots, to cut away the smaller ones to a depth of a few inches below the surface of the soil, and then to level the ground as evenly as possible. If the roots throw up fresh shoots, these latter will usually be very vigorous on the first year; but then they may be mowed at the same time with the grass as close to the ground as possible, and the quantity of hay is thereby increased. On the second year the number of shoots put forth is greater, but they are more weakly, and the roots themselves rarely survive the third year; in most instances they decay and die away, and thus become converted into manure. When this has taken place, there is nothing to prevent the land from being submitted to the action of the plow, and well turned up. If, on the contrary, the soil be converted into corn land before it has been carefully cleared of all the roots contained in it, the latter, favored by the tillage, put forth their shoots with great vigor, and their extirpation then becomes exceedingly difficult.

Next to the soil of ancient forests, waste lands and common pasturages are most generally cleared, after having been parceled out among those persons who can lay any claim to them, or after these persons have been authorized to bring their land into a state of cultivation. Land of this description is usually in a most disordered condition, the surface being rugged and uneven, and covered with mole-hills, ant-hills, and old stumps of trees and bushes. In the clearing of forests, the greatest difficulty is presented by the roots of the trees; but in the lands of which we are speaking, the main point to be overcome is the turf, which is always more compact and tenacious than that which is formed under the shade of trees, or has been constantly covered with leaves.

Many agriculturists have found great difficulty in destroying a tenacious and uneven layer of turf; there have, in fact, been some who were absolutely dismayed by the difficulties attendant on such an undertaking. Hence it has arisen that several plans have been devised for the purpose of attaining this end with greater facility, some of which have been put into practice. The following are some of the principal of them:—

1. The first, and that which is in most general use, consists in effecting the destruction of the turf by a year and a half or two years' fallowing. The turf is broken in the autumn, or after the ground has been sufficiently impregnated with rain, and care is taken in the first plowing not to turn up the soil to a greater depth than that occupied by the roots; supposing that the surface is sufficiently even to admit of the attainment of that end. The following method has been very strongly recommended to me for the purpose of effecting this removal of the crust of the soil, but I have not as yet put in practice:—A plow is to be used having a coulter and share, and no mould-board, which, consequently, cuts the turf vertically and horizontally without turning it up; behind this plow, in the same furrow, and arranged so as to penetrate to the same depth, follows a second plow, having a mould-board: this latter detaches the cut portion of the turf, and turns it completely over. It is evident that this mode of operation is calculated to succeed wonderfully well; but I have never yet met with any turf that could not be broken by the first operation of the plow, especially if, in cases in which the inequality of the surface prevented the cut portion from being completely reversed, I caused the plow to be fallowed by a laborer whose business it was to assist the turning up of the soil with his foot or with a pitchfork. Whatever may have been the tenacity of the turf, I have never harnessed more than two horses to the plow used for the performance of this operation: indeed, I have often employed only oxen. Oxen are not, however, so well adapted for this work as horses, when the soil contains a greater number of roots; because, though they certainly pull regularly, they are too apt to suffer themselves to be arrested by obstacles. Moreover, it will readily be understood that when cattle are employed on this work, it is necessary to feed them well, and to diminish the period of labor. If the layer of turf is very thick, it will be beneficial, first, to pass a harrow over it in the same direction with the plowing; and, subsequently, to roll it with a heavy roller, in order that it may be withdrawn from the action of air and light, and, consequently, putrefy and decompose, instead of putting forth new shoots. If any portions of an uneven surface should escape the action of the plow—an evil, which in many cases, is unavoidable—they must be broken with the spade or hoe, or they are liable to prove very injurious.

The soil should be left in this state during the whole of the winter, and even longer, until it has been watered by the warm rains of spring. During this interim, the harrow may, however, be passed over it a second time.

When the upturned turf begins to look green again, and to put forth new shoots from its roots, we may conclude that the lower part is dead. It is, however, necessary to obtain some more decisive proof of this before using the plow; for it is not advisable to turn up the ground a second time until such is actually the case.

The second plowing must then be performed in the same direction as the first, but penetrating

rather more deeply, in order that the divided portions of turf may be covered with a certain quantity of the lower stratum of earth. It is very injudicious to perform this second plowing crossways, because the furrow-slices are by that means cut in square pieces, which escape the harrow and cannot be divided by it. But if the furrow slices of earth, the tenacity of which is often diminished by fermentation, are merely turned up, the use of a large harrow will be productive of complete success, especially if this instrument is drawn by four horses and furnished with long teeth, and provided that its action is continued until the tissue formed by the roots has been divided as completely as possible.

The third plowing should be in an opposite direction to the other two, and should be executed with care and regularity; and subsequently, after a small harrow has been passed over the soil, it should be left in repose until it begins to put forth grass, when it should be plowed a fourth time, and after that the autumnal corn sown.

This complete summer fallow will be sufficient thoroughly to loosen and clear any soil that is of a warm, dry nature, and not excessively overrun with weeds; but it will not be sufficient for a moist, cold soil, the surface of which is uneven, and which is greatly infested with weeds, or with roots possessing a considerable degree of tenacity, life, and vitality. Nevertheless, many agriculturists do not go beyond this mode of operation, and make a point of sowing their land in the autumn, whatever may be its state and nature.

Where such is the case, the corn succeeds very well in some places; while in others it altogether fails, or is choked up with weeds. Satisfied with the crops obtained from the first-mentioned spots, these men hope soon to see it extend over the whole of the rest of the land. It cannot, however, be denied, that the losses which must result from so defective a system of tillage greatly exceed the advantages derived from this anticipated crop, and that it would have been better to have continued the fallowing for another year, in order to render the preparation and loosening of the soil more complete. At all events, I would never, in such a case, sow the autumnal corn; but rather plow the land two or three times more beforehand, and then, during the summer, cause it to bear a crop of plants, the perpendicularly descending roots of which, and the thick shade of their leaves, might lighten and enrich the soil; such as leguminous plants, buckwheat, and flax, which succeed remarkably well on rich soils, though they exhaust them a little. Potatoes, radishes, and other weeded crops, are likewise productive of this beneficial effect. I should not however, cause these to be succeeded by autumnal corn, but rather sow spring barley, intermingled with clover, which I should suffer to remain for two years. I am convinced that it is by pursuing this course the soil may, with the greatest degree of certainty and success, be brought into a state of permanent fertility. I have observed that clover seldom if ever succeeds on newly cleared lands, when the soil has not been prepared by the cultivation of the fallow crop.

2. The second method above alluded to consists in sowing a crop of spring corn, after having given one deep plowing to the land. It will be understood that this practice can only be carried into effect upon a soil, the surface of which is tolerably even, and not in any great degree infested with weeds; and, moreover, that the plowing must be performed with great care. Oats are generally preferred for this purpose; because, if they are sown pretty thickly, in rows, and in good time, and afterward well buried by harrowing, they succeed remarkably well, and produce plenty of grain, if not a large quantity of straw, provided always that the weather and temperature is favorable to them. Barley would not answer at all upon a soil that had been so little loosened. Many persons assert that they have obtained the greatest advantages from practicing the system here pointed out; and that when their land had been cleared of stubble, after the gathering in of the oats, they found it to be more completely loosened than it would have been by fallowing; so much so, indeed, that they were able o sow it immediately with rye. Others, and myself among the number, have found the turf so little decomposed, and the soil so imperfectly divided and loosened after the oat-harvest, that fallowing appeared indispensable; besides, the crop of autumnal corn which followed the oats was inferior to that which might have been expected, had the grain been sown immediately after the clearing. Nearly all the comparative experiments which have been made upon this subject tend to discourage the adoption of oats as a first crop.

On the other hand, I have, in common with other agriculturists, derived the greatest advantages from sowing flax upon the turf of a piece of cleared ground, after it had been well turned up, and when the soil was not too dry or too poor. This flax always attains an extraordinary length, and is of a particularly good quality. It is equally rich in fibre as in grain, and possesses this great advantage over that sown on fallow ground, namely, that it requires very little weeding. I put in the seed of this crop with the harrow, which covered it up very well, even though the plow had brought to the surface but a very small quantity of the earth beneath the layer of turf, properly so called.

When the soil appeared too dry to admit of the success of flax, I sowed millet in it, which, when cultivated with the hoe, or by hand labor, cleared off the greater part of those weeds which had sprung up among it, and somewhat thinned, succeeded admirably.

These two crops of plants always left the soil so light and friable, that the plowing performed for the purpose, of clearing away the stubble was sufficient to divide it completely, and the autumnal grain was sown upon it without any farther tillage. This mode of proceeding is, however, only practicable when the stratum of turf does not contain too many asperities.

3. The third mode of proceeding is to remove the crust of the earth with a hand implement or plow adapted for the purpose, divide the turf into pieces, and place them in heaps with stable manure or lime, which will assist in the decomposition of the vegetable matter, and then leave them in that state until the decomposition is completed; during this time to plow the soil which has been thus pared several times, subsequently to spread the compost over it, and bury it either by sowing in rows or by a thorough harrowing. This method, which I have tried several times, produces very abundant crops, and brings the land into an admirable state of fertility, because it ensures the absolute decomposition of the turf, its transformation into humus, and gives it a more

complete aeration than could be obtained in any other manner. But it is evident that this mode of proceeding must be more expensive than the others, and that it can only be adopted on small portions of land.

4. The fourth mode of proceeding is to burn the layer of turf. In my "English Agriculture," I have described this operation with regard to its application to soils which have produced grass for several years, and according to the manner in which it has been practiced from the earliest ages in several countries.

But I must here speak of this practice in relation to its application to uncultivated land, and show in what manner it must be employed on them, less completely it is true, but also at less expense; and lay down some instructions as to the most economical mode of putting it in practice on soils of this description.

First of all, recourse is had to the operation described in a previous page under the designation of half plowing, for the purpose of raising the furrow-slices of the the turf; that is to say, a slice is lifted up and turned over upon another by the side of it which has not been touched by the plow. This operation may be performed with any plow which has a broad, sharp share, provided it be held in a somewhat inclined position, so that on the side on which the yet unturned earth is situated the share may enter rather more deeply, and on that next the mould-board the divided furrow-slice may be very thin, so much so, indeed, that the lower angle of the plowshare may merely graze the surface of the ground. The plowshare is made rather wider than usual, and very sharp, and its base formed with a more obtuse angle than would be given to it if it were intended for ordinary plowing. The furrow-slice detached from the soil should not at most be more than two inches in thickness on the side next to the untouched earth, while it should be extremely thin on the opposite one.

When the soil thus prepared has remained for some time in this state, a strong harrow should be passed over it in a contrary direction to the plowing, in order to tear in pieces and break up those slices raised by the plow: small harrows, having the teeth pointed and curved in front, may subsequently be made use of, to detach the roots and fibres of plants from the earth by which they are still surrounded. When the surface has, by these means, again become level, those strips of turf which were left untouched during the first operation must, in their turn, be raised and turned over in a similar manner, and subjected to the action of the large and small harrows. The ground is thus covered with the roots and fibres of the plants of which the turf was composed. In dry weather, for it will readily be conceived that such is the proper period for the performance of these operations, all these plants and their roots are collected, first into small, and subsequently into large heaps, for the purpose of being burned on the ground. A period is chosen for setting fire to these heaps when the weather is warm and there is a little wind: straw, peat, or dry leaves, are made use of for the purpose of producing ignition. It is highly essential that the burning should be so managed that the heaps may consume gradually and without flame. To effect this they are pressed down, and, when lighted, covered, as occasion seems to require, with earth. After they are totally consumed, the ashes are spread over the surface, and buried by plowing the ground as superficially as possible. Any kind of produce required by the course of the rotation may then be sown. If, during the clearing of old forest land, a number of twigs and boughs should be left which cannot be used as fire-wood, and of which it is desirable to find some means of getting rid, they may be used to form the basis of the heaps which are to be consumed; and, by so doing, the burning will be accelerated and facilitated, and a greater quantity of ashes produced. The turf may, however, be completely consumed without the aid of any extraneous fuel.

Comparative experiments, conducted on the most extensive scale both in England and Scotland, have proved that burning is preferable to all other methods of clearing uncultivated lands, especially when they are of an argillaceous or marly nature.*

* This well-known operation of Agriculture, once much more extensively practiced in this country than at present, consists in paring off the turf to a depth of two or three inches, generally by a breast-plow worked by a laborer, or by a turf-paring plow drawn by a horse; allowing it to be dry, and then burning it in heaps. It is commonly best performed in the months of April and May. It is a practice now rarely adopted on sandy or calcareous soils; it is productive of good results on peat, and some kind of clay soil, but even there it is very doubtful whether it is the best mode of treating the land.

The practice is certainly as old as the days of Virgil, who mentions it in the first book of the Georgics. Endless have been the theories brought forward to account for its operation. Dr. Home thought it dispelled "a sour juice" from the land. ["Prin. of Agr."] Dr. Darwin thought it produced "a nitrous salt" in the ashes. "Many such obscure causes," says Davy, "have been referred to for the purpose of explaining the effects of paring and burning; but I believe they may be referred entirely to the diminution of the coherence and tenacity of clays, and to the destruction of inert and useless vegetable matter, and its conversion into a manure. All soils that contain too much dead vegetable fibre, and which consequently lose from one-third to one-half of their weight by incineration, and all such as contain their earthy constituents in an impalpable state of division, such as the stiff clays and marls, are improved by burning; but in coarse sands, or rich soils, containing a great mixture of the earths, in all cases in which the texture is already sufficiently loose, or the organizable matter sufficiently soluble, the process of torrification cannot be useful. "All pure, silicious sands," adds Davy, "must be injured by it;" and here practice is found to accord with theory. Arthur Young found "burning injured sand;" and an intelligent farmer in Mount's Bay told me that he had pared and burned a small field, several years ago, which he had not been able to bring again into good condition. I examined the spot; the grass was very poor and scanty, and the soil a silicious sand.

The process of paring and burning, therefore, seems to be most adapted for peaty or clay lands; for, as Davy continues, "The process of burning renders the soil less compact, less tenacious and retentive of moisture; and, when properly applied, may convert a matter that was stiff, damp, and in consequence cold, into one powdery, dry, and warm, and much more proper as a bed for vegetable life."

Frequently, when the surface of newly cleared land is uneven, it is necessary, in the first place, to smooth and level it, in order to facilitate its cultivation and render its surface homogeneous, or, in other words, more uniform in quality. This operation is attended with great labor and expense, and locality can alone determine the most advantageous mode of conducting it. When the inequalities of the surface are very close together, they may, in general, be reduced by throwing the earth from the tops of the ridges or elevations into the hollows with spades or some other similar implement of manual labor. For this purpose, men are stationed at certain distances proportionate to their strength, and employed in throwing the earth which they have either raised or received from those next above them, and thus passing it from the highest to the lowest portions of the land which is to be leveled. Should the distance be somewhat considerable, it will be necessary to make use of hand-barrows; if it becomes still more so, recourse must be had to wagons, or, what is still better, to dung carts with two wheels, or *shooting carts.*

In land which has been thus leveled, it too often happens that the elevated spots are deprived of the whole of their vegetable soil, which becomes accumulated in the bottom of the hollows; this evil is most inevitable, and cannot be remedied without great labor and difficulty. Should it not be possible to avoid this defect by throwing back the higher stratum of the soil, it will be necessary to compensate the elevated portions by bestowing on them a larger quantity of manure and more careful tillage.

The removal of large stones often increases the difficulty of clearing an uncultivated soil to a considerable extent, and yet they must be removed at least as far below the surface of the soil as the plow penetrates in its course, otherwise it is wholly impossible to till the ground properly; should it be attempted without this preliminary preparation, a great deal of time will be lost in plowing, and the work is sure to be badly and unevenly executed; besides, the implements made use of are very liable to be broken.

When such stones can be made use of in the construction of high roads, enclosures round the estate, or in the building of walls and houses, it is by no means uncommon for their value amply to compensate for the expenses incurred in extracting and removing them. If they cannot be used in this manner, the expense attending their extraction and removal may be diminished by sinking them in the ground to a depth at which they will not interfere with any of the operations of Agriculture. For this purpose, a trench deeper than the stone itself is dug all round it, and it is laid in the hollow thus formed. The width and depth of this hollow must be greater than the breadth and depth of stone, and its shape must be so contrived that the stone when turned over may not present either of its angles or edges to the ground. It is said that stones which were once buried to a proper depth in the ground have subsequently been observed to make their ap-

Davy examined three specimens of the ashes from different lands that had undergone paring and burning. "The great objection," he adds, "to this operation is that it destroys vegetable and animal matter, or the manure in the soil; but in cases in which the texture of its earthy ingredients is permanently improved, there is more than a compensation for this temporary disadvantage. And in some soils where there is an excess of inert vegetable matter, the destruction of it must be beneficial; and the carbonaceous matter remaining in the ashes may be more useful to the crop than the vegetable fibre from which it was produced." (Agr. Chem. p. 344.)

Liebig thinks that all the benefit of burning the soil is attributable to its thus obtaining increased powers for the absorption of ammonia. He says, "Soils which contain oxides of iron and burned clay, must absorb ammonia, which is favored by their porous condition; they farther prevent the escape of the ammonia once absorbed by their chemical properties. The ammonia absorbed by the clay, or ferruginous oxides, is separated by every shower of rain, and conveyed into solution to the soil. Powdered charcoal possesses a similar action, but surpasses all other substances in the power which it possesses of condensing ammonia within its pores, particularly when it has been previously heated to redness. Charcoal absorbs ninety times its volume of ammoniacal gas, which may be again separated by simply moistening it with water."—(Organic Chem. p. 90.)

And it is evident, from the experiments which Liebig gives at p. 207, that charcoal-powder is a very fertilizing application to some plants. The practice, however, of paring and burning is evidently one whose advantages the farmer and the chemist admit with reluctance. And it is very probable that by other means, such as the use of lime, &c., most soils may be cultivated with more advantage to the farmer by the avoidance of this expensive and destructive process. "My practice," remarks Mr. Pearson, "in the use of turf for various purposes, convinces me that all lands must be injured by paring and burning, save those lands, which are few and far between, that possess too much inert vegetable matter; or, in other words, lands that grow their crops to such a state of luxuriance, as to prevent the desired intent of the cultivator. Those lands which possess too much inert vegetable matter might also be improved by having part of their subsoils burned; but not by burning the turf even here, for that is the only thing that can be commended on the spot that will cause fermentation in the soil when it is plowed in."—(Quart. Jour. Agr., vol. x. p. 552.)

[*Johnson's Farmer's Encyclopedia.*

pearance on the surface, and it has been found requisite to bury them anew. There is no doubt with regard to the fact, but it may referred to a cause altogether different from the actual rising of the stone; the real state of the case is, that a portion of the earth by which the stone was originally covered may have been carried away by heavy rains or by the action of the water; or the progress of cultivation may have insensibly spread this earth over a greater extent of surface; or lastly, and as is the case in my land, the stones may have been buried to such a depth only as would prevent their being reached when the land is superficially plowed, as it is used to be, but altogether insufficient for that purpose when the plowing is carried to the depth to which I have lately carried it. It is, therefore, necessary to dig a much deeper trench for such stones than at first appears to be requisite; and the more so, as they may otherwise prove injurious to the fertility of the land in those places where they approach the surface.

If it should be deemed expedient to carry the stones off the land, it will be necessary to procure a cart adapted for that purpose, unless the carrying take place during the winter, when it can be performed by means of sledges.

Very large stones must be blasted, especially if they are to be made use of for the purpose of building. The most useful mode of conducting this operation consists in the use of gunpowder; but the execution of it should be entrusted to those only who have had experience in such matters, and who possess the proper instruments for the purpose. Many imprudent individuals have paid with their lives, or their health, the forfeit of their want of caution or skill in this operation; besides, the price of gunpowder causes it to be attended with no trifling expense. There is also another method of proceeding which possesses all the advantages of the last mentioned one without its disadvantages. This consists in heating the stone to a high degree, by means of a very fierce fire applied to one part of it only, and thus expanding it considerably. When the stone has been thus made intensely hot, water is poured upon it to make it crack, the effect being accelerated by powerful blows given with very heavy hammers; this latter expedient is not, however, absolutely necessary. A third method consists in piercing the stone in the direction of its veins, and introducing into the hole a cleft cylinder of iron, and then driving a wedge of the same metal in between the two halves of the cylinder. This mode of proceeding soon causes the stone to split; and although it takes longer time, and requires more labor than the others, it has a decided advantage over them in furnishing building stones of much greater beauty and with flatter surfaces. Finally, a quantity of water may, during the winter season, be introduced into a hole made in the stone to a sufficient depth; the aperture being then closed with some stopper closely driven into it. The water contained in this hole expanding as it freezes, exerts a force sufficient to break in pieces the strongest stones.

Quick-lime thoroughly calcined is the most efficacious manure for newly cleared land, especially if the upper stratum of the soil contain a considerable quantity of undecomposed vegetable substances. On land of this description, it is scarcely possible to apply lime in too large quantities. Many agriculturists have found it highly advantageous to use as much as five winspel per acre, when the price has been moderate. If this substance is spread over the surface of the ground previously to the plowing, and the tillage repeated several times during the summer, in order to effect a *complete admixture of the lime* with the soil, the former soon decomposes all the vegetable matters and converts them into very fertile humus. It likewise absorbs the acidity of the soil, and that tannin which is so injurious to vegetation; kills worms and insects, which sometimes multiply in land of this description to such an extent as totally to destroy the first crops sown upon it after it has been cleared. When newly cleared ground, rich in vegetable matter, has been thus manured, the most exhausting crops, even rape, may be grown upon it.

It must, however, be understood that lime is productive of but little effect upon a poor soil which contains only a small proportion of vegetable matter.

The soil of furze lands is not always sterile: its lower stratum often consists of a fertile clay, which amply repays the expense of clearing. Such soils also contain humus, but it is of a particular kind, and by no means favorable to the growth of anything but furze.

A year before the time appointed for breaking up a soil of this description, the

furze should be set on fire during dry weather, after having been previously allowed to shoot up in all its luxuriance. In order to prevent the fire from extending beyond that portion of ground which is to be broken up and brought into cultivation, an event which might be attended with considerable danger and damage by extending the fire to neighboring forests or plantations, care is taken to surround the space on which the furze is to be burned with a wide, shallow trench. The fire does not kill the furze; on the contrary, the plants put forth an abundance of new shoots on the following spring. These young sprouts of the furze are so grateful to sheep, that in some places the plant is set on fire solely for the purpose of obtaining them. The ground is then well stocked with sheep, care being taken to select for that purpose a breed which will accommodate themselves to, and thrive on, the young furze. During the ensuing winter the soil is broken up, and on the following summer plowed two or three times; and, if possible, sheep are penned upon it. This mode of proceeding, and the manure resulting from the sheep-fold, is peculiarly well adapted for the purpose of decomposing the humus of furze, sheep dung containing a considerable quantity of ammonia.

Very little benefit is derived from the use of lime alone when applied to cleared furze land: the ashes of wood, and even of turf, are much more efficacious. Argillaceous marl combined with animal manure is productive of considerable effect upon such land.

On a clearing of this nature, it is best to begin by sowing buckwheat; which, of all useful crops, is the one that accommodates itself best to such soils, and contributes most materially to change their nature. This kind of grain is often sown upon a second or third plowing, without any farther fallowing; it is very vigorous and luxuriant in its growth, especially when assisted with a little stable manure. It can be most advantageously used either as green meat or hay, and will thus become the means of producing the manure requisite for the amelioration of the newly cleared furze land. After buckwheat, rye will usually be found to succeed best upon such soils; but after one crop of it has been grown, the land must be left for some years in a state of repose or pasturage, if we would increase instead of exhaust its fertility; and in order to lay the foundation of the pasturage, Dutch clover should be sown in the spring among the rye. Whenever attempts are made to obtain from land of this nature all the crops it is capable of yielding at once, it sinks into a more complete state of barrenness than that from which it was rescued by the operation of clearing.

To endeavor to clear and bring into cultivation a soil which consists entirely of sand, is a more hopeless undertaking than that of building upon the sands.—There are but two cases in which such an operation can be performed with any degree of profit.

(*a*). When the land is situated in the neighborhood of towns where it fetches such a high price when cultivated, that it is worth while to endeavor to form a new stratum of vegetable mould upon it, by carrying to it and mixing with it a quantity of clay, mortar, rubbish from old buildings, and other kinds of matters conducive to vegetation, which may be had in abundance in the adjacent town.

(*b*). Or when it is situated where adequate artificial irrigation may be given to the sand, so that the land may be converted into meadows, or appropriated to the production of useful vegetables. Where this cannot be done, it is often not only disadvantageous, but exceedingly dangerous, to turn up a dry, sandy soil covered only with a light stratum of turf, and containing not more than five parts in a hundred of clay; especially when it is situated on an elevated spot, or in an open plain. It has not unfrequently happened that when a piece of land of this nature has been plowed up for the sake of obtaining from it a few scanty crops, whole tracts of fertile fields have been laid waste by being smothered in a cloud of this sand raised by the wind.

Should it be deemed desirable to bring a less barren sandy soil into cultivation, the first and most important step to be taken is to surround and even intersect it with hedges, so that the wind may carry away less of its moisture, that effect which is designated "the chilling of the soil" prevented, and the vegetation protected. As sandy soils are incapable of maintaining anything like fertility, unless frequently suffered to lie fallow or converted into pasturage, at least so long as their nature remains unchanged, it is so much the more convenient to divide them into enclosures and protect them with hedges, as by this means it becomes easier to keep cattle on them, and the animals, when placed there, are more sheltered from the wind, a circumstance which tends greatly to their ad-

vantage. It is likewise of great importance that such tracts of sand should be protected from the north and north-east winds by plantations of lofty trees.

It is often absolutely necessary to fix and consolidate the surface of a sandy soil by forming a layer of turf upon it, no matter how poor its produce may be, for the sake of protecting the neighboring fields from the devastations caused by the whirlwinds of sand. It is often exceedingly difficult to produce a growth of grass. Various species of plants which vegetate in sand have been proposed for the purpose, as sand Lyme grass (*elymus arenarius*), sand sedge (*carex arenaria*), couch grass (*tricticum repens*), creeping bent grass (*agrostis stolonifera*). These plants, however, seldom become perfectly established on the soil until the land is protected by hedges, because the shifting of the sand, when constantly agitated by the wind, prevents the seeds from germinating, or, at all events, hinders the germs from taking root in it, unless they have been sown during calm and damp weather.

When the sand is entirely naked and liable to to be agitated by every breath of wind, the only means of avoiding the evils likely to ensue is to enclose it by means of hurdles placed at intervals, and in sufficient numbers to prevent the wind from acting upon or raising it. This kind of fence should not be placed at those spots where the motion of the sand is to be arrested, but where it begins to assume a movable character. Indeed, it is useless to attempt to oppose any barrier to its progress, if the cloud advancing behind is not also stopped: whole forests and lofty trees have been known to be buried in this manner, even to the very summits of the highest boughs. But if the motion of the sand be first arrested on that side from which the wind begins to blow, and to lay hold of it, and that part protected from the force of the wind, then the attempt to put a stop to the accumulation has some chance of being attended with success.

These hurdles or fences are usually formed of the branches of the fir tree, and those are chosen for the purpose which still have their cones on, in order that the land may thus be planted with these trees, and they are placed at intervals of twenty or thirty paces apart. As soon as the motion of the sand is somewhat checked, hedges are planted extending from north to south, and their distance from one another is regulated by circumstances. If the sand is not very light, or the wind very impetuous, these hedges may be dispensed with, and the plantations of pine trees formed at once, so that the ground may be covered with trees and converted into forest land, which is by far the best mode of turning soils of this description to account. It would be useless to plant land of a sandy nature with fir trees without having previously taken the precautions above mentioned, unless indeed it had been covered with grass, in which case it may be successfully planted. A soil of this kind must not, therefore, by any means be completely broken up, if it is to be planted with trees; it should not only be plowed in alternate strips in the manner already described

If a sandy soil is to be made to bear useful grasses, it must not be very light, but must contain at least eight parts in a hundred of clay. When such is the case, the grasses which will be found best adapted for the formation of the turf are sheep's fescue grass (*festuca ovina*), red fescue grass (*festuca rubra*), hard fescue grass (*festuca duriuscula*), decumbent fescue grass (*festuca decumbens*), sweet scented vernal grass (*anthoxatum odoratum*), common cat's tail grass (*phleum pratense*), knot-stalked cat's tail grass (*phleum arenarium*), soft broom grass (*bromus mollis*), barren broom grass (*bromus sterilis*), soft holcus (*holcus mollis*), meadow holcus (*holcus lanatus*), meadow oat grass (*avena pratensis*), cat's tail canary grass (*phalaris phleöides*), and rye grass (*lolium perenne*). Should the soil contain some slight portion of humus, there may be added to these, black medick or nonesuch (*medicago lupulina*), bird's-foot trefoil (*lotus corniculatus*), common bird's-foot (*ornithopus perpusillus*), wild thyme (*thymus syrpillum*), common marjoram (*origanum vulgare*), common burnet (*poterium sanguisorba*), and Dutch clover (*trefolium repens*). If, at the end of a certain number of years a stratum of turf of sufficient thickness has been formed, and the land has been used as a pasturage for sheep, it may with certain precautions be make to yield two crops of corn; but the exhaustion which will result from such a course of proceeding must be compensated by manuring the land with dung. The first plants sown on it should be buckwheat and spurry, but they should be sown so

late in the season that instead of ripening they may be killed by the frost and rot upon the ground.

Should there be a quantity of marl or argillaceous mould within a convenient distance of a soil composed entirely of sand, this latter may be permanently improved, and its nature to a certain extent changed by carrying to it a portion of this marl or mould.

The clearing of marshes is an operation of greater importance than that of sandy soils; and one which is not unfrequently productive of great benefit; but as the drying or drainage of such places constitutes the chief and most important part of such undertakings, I shall defer treating of this subject until we come to speak of draining generally, and the various matters relating to it.

In most cases great advantages result from lands being enclosed at the same time that they are cleared; and besides, hedges are often indispensably necessary for the protection of lands newly brought into cultivation. For this reason, therefore, I shall here state all I have to observe in regard to fences, &c.

HEDGES, FENCES, AND ENCLOSURES.

Great diversity of opinion exists with respect to the comparative and advantages and disadvantages of hedges around arable land. However zealous the advocates of hedges may be, there are, on the other hand, many agriculturists who, not satisfied with discouraging the formation of them, even go so far as to recommend the destruction of those already existing.

The following are some of the disadvantages which are attributed to hedges:

1. They take up a great deal of room, and occupy ground, the loss of which is much to be regretted when the soil is of a good quality.
2. They prevent the land from drying, and, consequently, retard the seed time.
3. They cause the formation of large heaps of snow, which are a long time ere they melt and disperse, and thus they prevent the plow from being used at so early a period as it otherwise might. They likewise frequently overshadow and stifle those plants which grow near them.
4. They are complete nurseries for weeds. It is impossible to destroy the noxious plants which grow in them and, consequently, these latter extend their roots and propagate their seeds over the whole of the neighboring ground.
5. They likewise afford refuge to insects, vermin, and various mischievous creatures, and especially to sparrows and mice.
6. They impede the cultivation of the fields, and especially the operations of the plow, by preventing it from being driven to the very edge of the land, and increasing the number of turns which it is compelled to make in plowing a given space, which certainly is a manifest disadvantage.
7. They interrupt the communication between the fields, and often render it necessary to take a long circuit in order to get from one enclosure to another which is close by its side.
8. When they have ditches by their sides, the latter cannot always be made in the direction most favorable to drainage; so that the water flows back into them, swells over on to the land, interferes with the cultivation, and injures the crops. It is very seldom that enclosed land can be divided in such a manner as to admit of the ditches which surround it serving at the same time for the purpose of drainage.

On the other hand, the reasons about to be enumerated are advanced in favor of enclosures, and especially of quickset hedges:

1. The experience of all ages has tended to prove that fields surrounded with hedges are always much more fertile than those which are left unclosed. These fences are productive of beneficial effects in various ways, and especially as, by obstructing the course of the wind, they keep the land at a higher temperature. In the cultivation of gardens, the advantages of having the ground protected by hedges or walls from the power and effect of the wind are generally recognized. It is a well-known fact, that plants growing in gardens are always inferior in vigor and beauty in those parts where the fence is broken. The column of air heated by the rays of the sun during the day, protects the ground and the crops from the cold and chills of night. Besides, the lowest stratum of air contains the greatest quantity of those nutritious matters which are so essential to the support of plants; it is, therefore, advantageous to enclose this column, and prevent it as much as possible from being blown away by the action of the wind.
2. Whatever may be the use of fences in protecting vegetation, the favorable influence which they exert upon the health of cattle is still more evident and considerable. The more completely animals are sheltered from the wind, the better do they thrive while at pasturage. On this point, the experience and opinion of English agriculturists remove all shadow of doubt; and, consequently, a much higher rent is paid in England for pastures surrounded with hedges, than for those which are unenclosed, and the more so in proportion as the enclosures are of smaller dimensions—that is to say, in proportion as the number of fences is greater. According to some agriculturists, a field of fifty acres, divided into five enclosures, will fatten as many cattle as sixty acres of land all in one piece.*

* And because, while the cattle are feeding in one enclosure, the grass shoots up again undisturbed in the others, without being trampled upon by the feet of the animals, as it would be if the several spaces of ground were not separated by any enclosures.

3. The preservation of moisture by means of fences is rather advantageous than injurious. Dry and elevated land is greatly improved by being enclosed; and it is for this reason that the value of a sandy soil becomes so much increased when enclosed and subdivided by good quickset hedges.

4. The portion of ground occupied by the hedges, and thus withdrawn from cultivation, is amply compensated by the wood which the hedges furnish, especially in countries where fuel is dear: the more fertile the soil, the greater is the quantity of wood which the hedges produce, and, at the same time, the smaller is the extent of forest land existing in the district; so that, were it not for the amount of wood derived from the hedges, there would be an absolute scarcity of fuel.

The other disadvantages of which hedges and enclosures are said to be productive, are not of the slightest importance, and may easily be remedied, provided that care is taken to keep the fences in good condition, and prevent them from becoming infested with weeds.

From these contradictory opinions the following results must be deduced:

1. A great number of hedges may be injurious to a soil which is naturally damp and moist, by preventing it from drying quickly. On land of this nature the hedges ought always to be removed, excepting in the neighborhood of the ditches. While, on the other hand, hedges are exceedingly useful in dry situations, and on light sandy soils; and their utility in such places increases in proportion with their number. On land of this description, the advantages resulting from hedges greatly overbalance the defects with which, in some respects, they are chargeable.

2. If land be constantly kept in a state of cultivation, and used as arable land, and sown every year, then the utility of hedges is not so great, and may even be counterbalanced by the impediments and loss of time which they occasion in the various operations of tillage, and especially in plowing. But if the land be devoted, at alternate intervals, to the pasturage of cattle, or converted into permanent artificial meadows, then the advantages of hedges preponderate over their disadvantages, because they greatly facilitate the keeping of cattle, and provide a beneficial protection for them. This last consideration is an inducement to choose that period for the cutting down of hedges in which the land is devoted to the first crop of corn, so that they may shoot up afresh by the time it is again converted into pasturage. In order that this may be effected, the course of the rotation must extend through several years, as ten or twelve for example.

The same considerations will determine the propriety of giving greater or less extent to the enclosures. If the soil be moist, and intended principally for the growth of corn, the enclosures should be tolerably large; but if, on the contrary, the land be dry, and intended chiefly for the maintenance of cattle, it will be found advantageous to divide it into smaller parts.

There are two principal kinds of fences—*dead fences* and *quick fences;* the latter of which are generally designated hedges.

Fences of the former class are attended with a disadvantage from which those appertaining to the latter are free, viz. that they gradually become deteriorated from the time of their erection; whereas the latter, provided proper care and attention be bestowed upon them, become better and better every day.

The following are the dead fences in most common use:

1. *Walls.*—This description of fence can only be used in those places where there is an abundance of stone adapted for the formation of it.

It is only around yards and gardens that walls are built with mortar; those which surround fields are seldom or never constructed in this manner.

We often see estates surrounded with dry walls, built entirely with the stones collected on the estate itself, or in the neighborhood, and joined together with moss or turf. If we would have these walls at all durable, they must be partly composed of large, flat stones, by means of which some degree of uniformity may be given to their external sides. If any stones can be found of sufficient size to pass through the whole thickness of the wall, the solidity of the latter will be increased: round stones may be used for the inside of the wall and for filling up the empty spaces. Should the number of flat stones be small, the wall must not be built very high: it may then be covered with turf, and gooseberry or other bushes which grow very well in such situations, planted on it. The roots of these bushes penetrate into the earth which is placed between the stones, and, consequently, tend to increase the solidity of the wall; and, what is of still more consequence, they likewise increase its hight and oppose an obstacle to the intrusion of men and animals.

Stones are sometimes used to form low walls or parapets, broad at the base, but narrow or rounded at the top. In these the stones are mixed with earth or turf, and covered with the same material: such bushes as will grow there are planted on the top to form a hedge.

The chief advantage of walls and fences of this description is that they occupy but little space, and allow of the ground being plowed up to their very bases. Even if they are not very durable, it is, at all events, easy to keep them up and repair them when the requisite materials are to be found on the spot. It is, therefore, exceedingly desirable that they should be erected in all places where, in order to give value to the land, it is necessary to clear the fields of stones, and where there is no means of making a better use of such stones.

Sometimes it is considered sufficient to mark out the boundaries of the fields by lines of stones sufficiently high to stop the teams; and occasionally a hedge is planted behind these border marks, for the purpose of protecting them. Sometimes, too, these stones are used to form a path for foot-passengers when the road is full of water, in order that they may not trample upon the ground in which the seed is sown.

Those walls of earth, either in a soft or hardened state, which are found in some countries, but which are more frequently used for the purpose of enclosing yards and gardens than arable land, last but a very short time and require frequent renewal. Sometimes it is not thought inconvenient to renew them, because the clay of which they are constructed acquires considerable fertility by being exposed to the influences of the atmosphere, and greatly enriches those soils on which it is placed, especially when these walls have been erected in villages, or in the neighborhood of dung-heaps, and the clay has consequently become impregnated with nutritious matters. But the clay used for this purpose must be procurable in the immediate vicinity; for the carriage of it from any considerable distance would be attended with an expense which, from the perishable nature of the walls, would soon become enormous.

Fences of dead wood.—These fences are sometimes constructed by means of posts fixed in the ground, and thus made to form palings of various kinds. Pieces of split wood, the points of which are fastened to a cross-piece either by nails or joints, or which are attached to one another by means of sticks woven among them like hurdles, form a kind of fence which consumes more wood than any other, and yet possesses but little durability. Posts driven into the ground to sustain rods or laths extending from one to another, and fitting into holes or mortices made for the purpose, form a fence which is capable of preventing the egress of large cattle, but which will not keep in smaller animals, unless the cross-pieces are very numerous and placed very closely together—in which case the posts will be considerably weakened by the closeness of the holes bored in them. On this account, some persons merely place the posts side by side, and connect them together with rough pieces or branches of wood.

I shall not enter into a description of the other varieties of lath fences, or of the more complicated forms of paling, because, on account of the expense of erecting them and keeping them in repair, they can scarcely be made use of excepting for the purpose of enclosing gardens; still less shall I stop to give an account of those which are made of boards joined or nailed to each other.

Fences are sometimes made of pieces of wood twisted together, where plenty of branches can be obtained. This forms a solid and durable fence, especially when the separate pieces which support it consist of wood which takes root and continues to vegetate for some time. Fences of this kind are constructed in various ways. All those formed of dry wood, though still often met with in various parts of Germany, will soon be proscribed, because the scarcity of wood, or, at all events, the great economy which is introduced into the use of it, will not allow the continuance of such a practice. In villages, where fences of this sort are usually found, they have the great disadvantage of communicating fire from one cottage to another with almost incredible rapidity; so that when a fire breaks out, if these fences are not quickly pulled down, a whole village becomes, in a few moments, a prey to the devouring element.

Mounds, or ramparts, or banks of earth.—These are usually defended on both sides by ditches, from which the earth of which they are formed was dug.—They are usually covered with a hedge planted on the top; or, if the land be well drained, it may be planted on the sides or on the edges of the ditches.

The most solid banks of this description are formed of turfs placed one upon the other; and on sandy soils they can scarcely be made in any other way. But as it seldom happens that it is possible to obtain the turf for the formation of these banks from any extraneous source, it is necessary that land which is to be thus surrounded should not only be covered with a stratum of turf, but be continued in that state for several years, in order that the stratum may have acquired sufficient consistence for the purpose. This kind of fence is generally adopted where the object of enclosing land is to bring old pastures into cultivation and to prevent ingress.

These banks certainly take up a great deal of room; their breadth, including that of the ditches, amounting to sixteen or eighteen feet: the inner ditch may, however, be gradually diminished in breadth.

The following are the principal operations relating to the formation of these banks. The lines which determine their width are traced by means of a cord and a spade; the space usually allowed is eight feet. The space assigned to the ditches is marked out in a similar manner; the proper width for them at the top being four or five feet. The surface of the ground on which it is intended the bank should stand is then broken up, and the upper layer of the turf, for the space of about a square foot, removed to the depth occupied by the roots of the plants; and the mould which adheres loosely to it shaken off. About half a foot of turf is left undisturbed at the edge of the base of the bank; and upon this border, on both sides of the bank, the first row of turf-slices is placed, the surface on which the grass grows being turned downward; the pieces are laid perfectly level and close together, and somewhat, although very little, farther back than the edge of the bank, so that they may begin the slope. The space between the two rows is filled up with earth taken from the ditches: care is taken to keep the earth within the space well pressed down, and in a level with the layer of turf. A second row of turfs is then placed on the first one, and the pieces composing the latter are carefully disposed so as to cover the joinings of the former; the arrange-

ment of them being similar to that of tiles upon a roof. The second row, as well as the following ones, ought each to be a little way farther back than the edge of the one which preceded it, in order that the slope may be regularly continued. The best mode of regulating this slope is to provide the workmen with gauges made of laths united together, and constructed in such a manner as to determine both the size and form of the bank. These may be placed at certain intervals, and lines stretched from one to another. When the hight of the bank, measured from its base, is to be about three feet and a half, the breadth of the ridge may be three feet; the slope of the sides being such as to reduce the eight feet of the base to this width of three feet at the summit. In arranging the turfs, care must be taken to place that edge which is most evenly cut outward; this edge should likewise be cut in a direction parallel with the surface, so that it may naturally tend to form the slope. Where such is not the case, when the bank is finished all the irregularities must be cut away, so as to form an even surface. Each row of turfs should be carefully beaten down, and flattened on that which precedes it, but not so violently as to break it. It has already been observed that the space between the two rows must be filled up with earth and well beaten, so as always to form an even surface.

This operation is usually commenced in the autumn, and continued until the bank has attained the hight of a foot and a half or two feet; it is then left in that state during the whole winter, in order that the earth may have time to sink down and become compact. The operation is finished as early as possible in the following spring, before the weather becomes very dry, in order that the turf may have time to recommence vegetation. Those slices of turf which have been cut may, without incurring injury, be suffered to remain in that state during the whole of the winter; they must not, however, be piled one on the other, but spread over the ground in their natural position.

If the turfs cut from the bottom of the bank and the surface of the ditches be not sufficient to form the mound—a point about which no general rule can be laid down, since it depends on the greater or less thickness of the turfs—it will become necessary either to take up the surface of a large portion of the ground, or to obtain turfs from elsewhere. The latter course must likewise be resorted to when banks are to be formed in places where grass does not grow. When the proper inclination is given to each side of the bank, the earth taken out of the ditches will be exactly sufficient to fill up the empty space between the turfs.

When the soil is very argillaceous, and possesses a considerable degree of tenacity, the use of turf in forming the bank may be dispensed with. In such a case it will be sufficient to cover the surface only with turf, after the bank has been formed of the earth taken from the ditches. Should the soil be naturally humid, this latter mode of proceeding is more to be depended on than any other, because the turfs obtained from such a soil being naturally spongy, and full of moisture and moss, soon decompose and fall to pieces when laid one upon the other. Where merely sufficient turf is required to form this covering, the quantity raised from the surface of the ditches will in general suffice; and, in this case, the grass bearing soil at the bottom of the bank need not be disturbed, but may at once be covered with the earth taken from the ditches, and the bank constructed of the form already described. But then greater care must be taken in cutting the turfs with which the bank is to be covered, and especially when they are thick. They must be cut in a direction oblique to their surface, so that, when placed upon the slope, they may fit into each other exactly, and the lower edge of each turf may adjust itself above the upper edge of that which lies below it. It will, of course, be understood that this covering up of the bank must be commenced from the bottom; it is likewise necessary, not only that the first row of turfs should be of the same width throughout, but also that all the individual pieces of which it is composed should be of one uniform breadth. When this first row is finished, another is placed upon it, the turfs being adjusted to each other with all possible nicety, and so as to join evenly together, with the lower edge of one row slightly overlapping the upper edge of the one beneath it. Before the turfs are put on, the earth should be well beaten, so that it may present an even surface, and that no hollows may be formed in it.

A hedge should then be planted either on the top or at the side of the bank, and in a manner which we shall presently describe.

In moist situations, ditches without banks are preferable for the formation of enclosures: we shall treat more at large of the manner in which these should be formed when we come to consider the subject of drying and draining soils.

The planting of quickset hedges is effected in various ways; sometimes on raised banks, at others on level ground. These hedges are composed of various plants; sometimes of one species only, at others of several mingled together. The following are the plants generally selected for this purpose, and best adapted for it:

White or hawthorn *(crategus oxyacantha)*, dog or wild rose *(rosa caninis)*, hazel-nut tree *(corylus avillana)*, elder tree *(sambuca nigra)*, hornbeam *(carpinus betulus)*, gooseberry bush *(ribes grossularia)*, black-thorn *(prunus spinosa)*, common birch *(betula alba)*, narrow leaved English elm *(ulmus campestris)*, willows and osiers *(salix)*, acacia *(robinia pseudacacia)*, brooms* *(genistæ)*, common privet* *(ligustrum vulgare)*.

The common barberry *(barberis vulgaris)* was formerly often used for this purpose, but its use is now quite abandoned; indeed, it has been discovered that this plant is very injurious to the corn growing in its neighborhoood, and that its pernicious influence will extend to a period of fifty paces.

* The author adds, that in the north of Germany that part of these plants which is above ground is often destroyed by the frost, but that they put forth fresh shoots.

Among this number of plants, care must be taken to select those which are best adapted to the nature of the land; the species which grow wild upon the soil are, undoubtedly, those which it is best capable of nourishing, and which may, therefore, with the greatest degree of probability be expected to thrive upon it. Nevertheless, when a soil is well prepared, plants with which it does not at first seem to agree, may often, by dint of care and culture, be made to grow upon it. Wherever there is any doubt with regard to the subject, it is prudent to mix such stranger plants with others which are indigenous to the soil, and may fill their places should they happen to fail.

Of all the plants used for the formation of hedges, *white-thorn* or *hawthorn* is the one best adapted to the purpose. It forms an almost impenetrable fence, grows very compactly, and does not throw out new ramifications from its roots into the surrounding soil; neither does it choke the plants in its vicinity, nor spread out its branches to any very great extent; and it may be managed so as seldom to require cutting, and then not to any great extent at a time: all animals avoid it on account of its thorns. It does not harbor birds or insects, and when once fairly fixed in the soil, allows but few weeds to spring up around it. But it requires a good soil containing plenty of clay, or else garden mould; and will not thrive either where the ground is excessively dry, or where it contains any great quantity of moisture.

This plant is sometimes found growing spontaneously in copses, but such an occurrence is by no means usual; the artificial planting of it in nurseries possesses great advantages over any other means which can be resorted to for the purpose of obtaining it. Young hawthorns thus reared succeed much better than those taken out of forests, and which have consequently grown up in the shade; the same may indeed be observed with regard to all shrubs used in the formation of hedges. This circumstance should induce agriculturists to establish nurseries, from which they may obtain the plants required for the construction of their hedges. It is true that these nurseries require great care and attention, but where this can be devoted to them it will generally be found that the young plants reared there are not only much better, but cost less in the end than wild ones taken out of the woods would have done.

White-thorn is, of all shrubs, the one which there is the greatest difficulty in rearing; but in the end it well repays the care requisite to ensure its success.

The seed of this plant, which is enclosed in a red fruit, is gathered in the autumn, and immediately sown in rows in a good soil which is light and not too rich, or else it is placed in pots filled with good mould, and kept during the winter in a humid state and in a warm temperature. It is said that watering with pork-brine facilitates the germination of this seed.

When the seed of the hawthorn, after having been thus prepared, is put into the ground at the commencement of spring, it sometimes shoots up and forms young plants in the first year; whereas if this course of proceeding be not adopted, it does not spring up until the second, and sometimes even until the third year. In order to protect the seed when placed in the ground from the attacks of insects, mice, and other vermin, the earth surrounding it is mixed with broken glass, or other substances of a similar nature, and it is then covered lightly with earth. The nursery must be carefully kept clear of weeds; and, in order to effect this, the rows in which the seed is sown should be kept quite distinct, so that the space between them may be dug up with the spade.

In the second year after germination the young plants should be transplanted. The tap root must then be pruned, as well as those roots which extend in a horizontal direction, so that the young plants may put forth as much foliage as possible round their stems.*

The hawthorns are placed close together, but in rows sufficiently distant from each other to admit of their enjoying the influence of the sun and air. The more frequently the space between these is tilled and weeded, the better do the plants thrive. In gardens this cultivation should be performed with the spade or hand-hoe, but in large plantations in the open country it may be performed by means of a plow or horse-hoe. In the first year the implements of cultivation should be made to approach as near as possible to the rows, in order that the horizontal roots of the plants may be thus cut off; but in the second year the cultivation should not be brought so near them; finally, it is not judicious to heap the earth in any considerable quantities against the plants. The young hawthorns should be suffered to remain in the bed for three or four years, in order that they may attain the condition most favorable to their final transplantation.†

Some persons have advised that a poor soil should be selected for these nurseries, in order that the plants may not become habituated to a great degree of fertility. Other agriculturists maintain an opposite opinion, and prefer plants which have acquired vigor from growing on good grounds.

When the time comes for transplanting the hawthorns to the place in which they are to form a hedge, the soil must be well prepared to receive them. If they are to be planted on a bank formed in the manner already described, their removal may be effected as soon as the bank is finished. The best of the soil, or that which is immediately over the turf and which becomes detached from it, should be preserved, in order that it may be placed at the top of the bank and piled round the roots of the plants. But if the hedge is to be planted on a flat surface, the best way is to dig up a

* I cannot believe that it is advantageous to cut away the tap root of bushes, the lateral roots of which ought not to spread out much. [*French Trans.*

† In March, 1826, I caused a quantity of hawthorn seed to be sown in one of my nurseries at Mossa-lomborda, which seed, I had taken care to bring into a germinating state, by putting it in mould at the commencement of the autumn of 1825, and keeping it during the whole winter in a moist state, and at a high temperature. This sowing furnished me, in the autumn of 1826, or in that which followed the spring in which it took place, with 27,000 plants; all of which were transplanted to the places where they were required, either in that autumn or in the following spring land succeeded perfectly well. Some of these plants had in the year 1829 attained a hight of 1·33 metres. [*French Trans.*

strip of land about six feet wide and two feet deep. In places where the expense of such an operation would be too great to admit of its being executed on a large scale, it will be sufficient to till this strip of ground several times with a plow during the summer, carrying the first operation to the utmost possible depth; by this means the soil will be thoroughly loosened and cleared of weeds.

The little trench in which the young plants are to be placed must be opened before winter comes on; this trench is usually made about a foot in depth. The soil will thus become loosened and improved, partly by the effect of frost, partly by the influence which the atmosphere exerts upon it in the winter. The young trees should be planted as early as possible in the spring, even if a continuance of cold weather and frost is expected, and should be put in the ground immediately after their removal from the bed; but at this transplantation their roots should not be pruned, but merely a little cut off their branches. Care must be taken to place those plants which are possessed of equal vigor as much as possible together; while those which are more weakly should be left in the bed, or else planted together in one portion of the hedge, so that special care may be devoted to them. The practice of mixing strong and weakly plants together, though highly recommended by some authors, is undoubtedly a bad one, for it causes the weak plants to be impoverished and choked up by the stronger ones.

Should there be at hand a little black garden-mould or well prepared compost, it may, with great advantage to the plants, be put into the trench above the roots; and the poor soil taken from the bottom may then, without risk, be placed above the mould, to prevent the weeds whose germs are contained in the soil from springing up. The plants are placed in a row at intervals of from six to twelve inches. If they are vigorous and healthy, they need not be placed nearer to each other than twelve inches. Sometimes two rows of hawthorns are planted for the sake of obtaining a very strong hedge, but in this case there must be a distance of at least two feet between the rows. Most cultivators plant the young hawthorns in an inclined position, and almost lying on the ground, so that they touch and cross one another. This is done with the view of making them grow in this oblique direction, and interlace spontaneously; but the result does not always correspond with the intention: the new shoots invariably grow in a direction nearer to the vertical than otherwise; and, what is more, the stems and branches rub against and injure one another. I have always found it much more advantageous to plant the hawthorn in the ordinary vertical direction; it is only the lateral shoots which can be made to interlace.

This interlacing of the branches is much accelerated by twisting the young shoots one over the other, and fastening them with rushes or small osiers; but this operation is a very troublesome one, and is therefore seldom practiced, excepting in gardens or grounds of but small extent. It may, in fact, be altogether dispensed with, since the branches of hawthorn gradually become naturally interlaced, provided only that the hedge be properly attended to, and its growth not too much checked by the bushes being cut down close to the stem.

In order that the hedge may be well clothed with branches near the ground, it is advisable that, within a year after the hawthorns have been removed to their place of destination, they should be cut down within two inches of the ground. They then throw out a proportionately greater number of lateral shoots from the stump, which shoots must be allowed to grow freely, and not too much shortened. When pruned with the knife or scissors, according to the method practiced by gardeners, it is sufficient to cut away the shoots which rise in a too vertical direction, and suffer the lateral branches to grow. Not even for the sake of thickening the hedge at the bottom, must the principal branches be cut down too low, or pruned too frequently, even when they have a tendency to rise straight up in the air; for when that is done, a new tuft of shoots is put forth, and a sort of crown formed at the place where these prunings have taken place, and the upper part of the bushes becomes too heavy in proportion to the stem; which disposition of the parts produces an effect precisely opposite to that which was intended, for the lower branches are thus weakened, and the bottom of the hedge becomes more and more naked. Hence, then, it is evident that, during the first few years, the top of the hawthorns should be only moderately pruned, and the lateral branches suffered to grow to their utmost extent. It afterward becomes necessary to cut them, but this must not be done in the manner practiced in gardens, the hedges of which are trained to form a sort of perpendicular wall, and are not so thick at the lower as at the upper part; on the contrary, the hedges of which we are speaking must be left as bushy as possible at the lower part, and that thickness gradually diminished toward the top. By a careful adherence to this plan, they may be made to retain their form, kept thick and well clothed to the very bottom, and rendered impenetrable. Subsequently, it will be sufficient to prune these hedges once in five or ten years; occasionally cutting away those shoots which grow too vigorously at the top, as may appear necessary. A hedge of this kind may be suffered to grow to the hight of three feet and a half, without ceasing to be well clothed with leaves and branches; at that hight it forms an excellent fence, and its goodness is increased in proportion as it is wider near the ground. A hedge of this description lasts a very long time; some may be found which have lived for upward of a century, and are still in good condition.

Hedges of *black-thorn* and *dog-rose* are seldom formed by artificial planting; but, for the most part, grow naturally, springing up from the shoots which proceed in abundance from the roots of these plants. Shrubs of this kind may always be transplanted to any place, for they easily take root and are very hardy. They are seldom pruned, but allowed to grow freely; the only difficulty connected with them is to keep them within proper bounds, for they have a great tendency to extend themselves and take possession of the soil which surrounds them, by means of the numerous off-shoots which their roots send up. In the formation of hedges, these shrubs are seldom used by themselves, but mixed with various others.

Hazel-nut hedges are usually formed by sowing the nuts in rows, on the spot from which the plants they are intended to produce are required to grow. Such hedges thrive remarkably well upon newly formed banks, because the soil of such places is, in a measure, well tilled, and also because the turfs which they contain protect the plants from the effects of drouth by their decom-

position; and, moreover, when planted thus high, they are more out of the reach of weeds than when in the open fields. The land must first be prepared for the reception of these plants, as well as for that of hawthorns, by careful tillage with the spade or plow, and then the furrow formed in which the nuts are to be sown. This furrow should be made as early as possible, in order that the surrounding soil may have time to become aerated. In the autumn, the earth taken out of the furrow should be mixed with mud from the bottom of ditches, or dry leaves.

The nuts intended for sowing should be perfectly ripe. The best plan is to select for this purpose only such as fall spontaneously in the autumn, when the branches which bear them are shaken. These should be kept during the winter in dry sand. In the spring they must be placed in the furrow prepared for their reception, and sown in rows at intervals of four inches. I have found that it is injudicious to place them in the ground before the commencement of winter, because they then run a great risk of being eaten by mice. Generally speaking, the plants make their appearance in May, and by the end of the summer have attained a hight of somewhat more than a foot. When they are too crowded, the alternate ones should be pulled up, and transplanted to places where there is room for them.

Hedges of hazel-nut trees only require attention during the first year of their growth; they must, for that period, be kept scrupulously clear of weeds. Subsequently, they should be cut down close to the ground every nine or ten years, and may by this means be made to furnish plenty o wood, which is of great use in cooperage, and they soon shoot up afresh with renewed vigor.

Hornbeam trees are reared in nurseries established for the purpose. This tree used to be in great request for the formation of hedges in gardens, and, indeed, when well pruned, it constitutes a very compact green fence; but without such treatment, the lower part of it soon becomes naked, and it has a tendency to shoot up to a great hight; in this case, especially if it be planted in double rows, it forms a fence like one composed of stakes, and not a hedge, properly so called.

The same may be observed with regard to the *narrow-leaved elm*, the *birch*, and the *elder* tree, unless their branches are occasionally lopped so as to make them put forth new shoots, or unless they are subjected to the treatment which we shall presently describe.

The rapid growth of the *acacia*, and the prickles with which its branches are armed, seem to render it peculiarly adapted for the formation of hedges; and many authors consider it to be well calculated for the purpose; nevertheless, I have never succeeded in forming a compact hedge with this tree. In fact, the acacia puts forth such vigorous shoots that they soon become woody, and cannot easily be restrained within the dimensions of a hedge. If, on the other hand, it be allowed to grow upward, the lower part soon becomes bare, and thus the fence is spoiled. It is possible, however, that I may not have adopted the proper mode of managing it.

In hedges consisting of shrubs of various kinds, the acacia may produce a very good effect by means of its prickles; but these latter tend greatly to increase the difficulty of cutting and pruning the hedges, and bending and interlacing the branches, in order to render the fence compact.

Hedges of prickly *broom* may easily be raised from the seed, by sowing it in the spot on which it is intended that the plants should grow; they form a tolerably compact fence, and possess but one bad quality, which is, that during severe winters they are almost invariably killed by frost.

Privet hedges do not form good fences.

The various species of *osiers* cannot be said to form a very compact hedge; nevertheless, a very useful kind of enclosure or fence, for the purpose of keeping cattle from straying, may be constructed of them. They are frequently employed with advantage for the purpose of protecting newly formed banks or mounds of earth from the attacks of cattle; and, for this purpose, are planted between the foot of the bank and the edge of the ditch; or else on the slope of the former, when it is intended that a hedge should be raised on its summit. In this case, osier twigs of about two years old are taken, cut into slips of from a foot to a foot and a-half in length, and planted, at intervals of two feet, so deeply in the ground as not to rise above three or four inches above the surface of the soil. After the first year these slips put forth shoots, which may be attached to each other. When the hedge on the bank is sufficiently advanced in growth to no longer need defence, the osiers may be taken away.

In very dry places, the kind of osier best adapted for this purpose is the brittle osier; but in moist, damp situations, where there is no other means of forming a hedge, that species of osier should be chosen which is best adapted to the nature of the soil, and then the mode of proceeding just described had recourse to.

Fields are frequently enclosed with hedges formed of several of the different kinds of trees and shrubs of which we have just been speaking mixed together, and planted either on an even surface or on an embankment; but in these cases the hawthorn is seldom or never used. Sometimes the hedge is formed solely of oaks and beech trees, and it is then managed in the following manner, which the Germans call the *knick* method of proceeding.

When the trees of which the hedge is to be composed have taken root, they are cut down within a few inches of the surface of the ground, and nothing left standing but a stem of about four feet high, to serve as a stake. These are left at intervals of four feet apart. Should there be any space which cannot be filled up by one of these stakes, a branch of osier may be planted there. Great care must be taken to keep the row as even as possible, and about every twelve feet a tree must be left untouched. The ditches should then be formed, and the earth taken from the bottom of them thrown against the hedge. This must always be done whenever the ditches are cleaned out or repaired; for it would be highly

injudicious to make any other use of such earth which belongs to the hedges and serves to manure it.

When the trees which have been left unpruned have grown up, two notches are made in the stem; the first very near the ground, and the second higher up. These ought to be of such a depth as to leave only the bark and a little wood remaining on one side. This tree is then bent on the opposite side to that in which the notches were cut, and interlaced with or tied to the stakes of which we have before spoken. The trees thus trained continue to vegetate, and in time produce a strong, compact hedge. This mode of proceeding is principally adopted with regard to hedges chiefly composed of hazel and birch trees. I have seen close, compact hedges thus formed on the most sandy soils; but this practice is seldom adopted upon places and in situations more favorable to vegetation, because the rain water which drops from the places where the stems are tied or interlaced, injures the young shoots and prevents the hedge from becoming covered with foliage.

On very fertile land it has often been found advisable to cut down hedges of this kind close to the ground every tenth or twelfth year, and then to suffer them to shoot up again at will. This practice is to be recommended not only because a larger quantity of wood is thus obtained, but also because, on land which is submitted to a rotation in which several years are devoted to pasturage, the hedges may be dispensed with during the period that the soil is tilled, and the crops thrive better when it is cut down.

If the farmer wishes to form a live hedge upon an even piece of ground, without ditches or embankment, it is absolutely necessary that it should be protected against the injuries liable to be done to it by cattle, as well as from those which may arise from the carelessness or wantonness of persons employed in or passing through the field, by a fence of some kind, which need not be constructed with more strength than is absolutely necessary to enable it to afford protection to the young hedge, until it is capable of taking care of itself. Whatever may be the nature of this temporary fence, it should be placed at some distance from the hedge—as, for instance, three, or even four feet; for, if it were nearer, it would deprive the young shrubs or trees of the air and light absolutely indispensable to their vegetation; and, when removed, that portion of the green hedge which had been shadowed by it would be so much affected by the suddenly increased amount of air and light thrown upon it, that the weaker plants would be liable to become diseased. If, on the other hand, the fence be too far off and too open, it does not protect the shoots of the young hedge from the attacks of cattle; and, consequently, the vegetation of the plants is retarded, and their growth stunted. Neither should a foot-path be allowed to be established by the side of a young hedge, because the pressure of the feet of passengers, and the friction caused by their passage to and fro, is calculated to injure it materially, especially if it be composed of hawthorn.

The formation of enclosures and the judicious distribution of land, which may be effected by means of good and compact live hedges, contributes essentially to increase the value of property, by enabling the agriculturist to raise various kinds of products from it, and pasture various kinds of cattle on it at once. Robberies and damage occur less frequently on enclosed than they do on open fields. Besides, in my opinion, a province which is intersected with ditches and embankments of earth planted with compact edges, presents almost invincible obstacles to all hostile invasions, especially if it is properly defended by a well disciplined troop of light infantry. The enemy's cavalry and artillery would make little or no progress over it. The whole country would become a continuous fortress; and if, as might easily be managed, these ditches and embankments were constructed with some regard to military tactics, the country might thus be far better defended than it could be by means of fortifications; and it would be much less expense to Government thus to make the whole country one uninterrupted fortress, than it now does to establish those fortifications around towns and villages which are so detrimental to the agricultural interest.

THE DRAINING OF LAND.

The ascertaining and adopting the best possible means of freeing land from prejudicial excess of moisture, may be ranked among the most import-

ant branches of agricultural science. The draining of land and rendering it healthy must precede all other improvements, as without in the first instance fully accomplishing this object, the farmer will find all his future exertions of little avail. A proper degree of drainage tends to protect the crops from the injuries which are to result from excess of moisture, and contributes materially to ensure their success. This operation alone has often been sufficient to render extensive sterile plains exceedingly fertile. But the art of draining is one of the most difficult and complicated of all those appertaining to agricultural science. It would be useless and impossible to attempt to point out all the different circumstances under which this operation has to be performed, and the modifications which must be introduced into it, since each one has its own peculiarities, and requires to be treated accordingly. It will be sufficient if we endeavor to give our readers a clear notion of the laws by which the motion of water is governed, and the manner in which it affects solid bodies; or, in a word, the various causes which tend to produce excessive humidity, that my readers may be enabled to distinguish them at a glance, and determine at once, in each particular case, the cause by which it is produced. This being ascertained, the most efficacious means of remedying the evil, and those best adapted to the situation and locality, will present themselves. It may be supposed that any remarks on this subject ought to prefaced by a dissertation on the theory of hydraulics, hydrostatics, and the mathematical principles on which this portion of the sciences depends. But as it is simply my intention to enter into such considerations as every agriculturist may be supposed to be acquainted with, I shall content myself with describing what may be understood and performed without reference to these branches of science; or, in other words, those operations which come within the sphere of action of every practical agriculturist; and under this class, the drainage of extensive plains, the means of protecting them from excess of moisture by large dykes or conduits, and the formation of canals, &c., cannot be comprehended. Undertakings like these come within the province of, and ought to be confided only to skillful engineers, who have made such matters their principal study; and even such men are frequently liable to commit errors, and show by their manner of proceeding that there is much regarding this branch of science yet to be learned.

It is a well-known fact, that water, by reason of the want of adherence between its parts—a circumstance which constitutes its fluidity—has a tendency to occupy with each of its molecules the lowest spot which it can find; and thus to seek a level, or form an horizontal surface. This fluid does not act merely on its base with a power proportionate to its weight, but its action likewise extends to the sides: its pressure is prolonged so long as the adherence of its particles remains unbroken. This accounts for the fact that when water is introduced into two tubs, the inferior extremities of which communicate with each other, its water assumes a horizontal position; that is to say, it rises to an equal hight in each tube, or, in other words, finds a level. An alteration of the dimensions of the tubes will not prevent this. Even when one is larger than the other, the water rises to the same hight in each; because, in general, the atmospheric pressure is not at all impeded by friction. But when one of the tubes is very much smaller than the other, the water will rise higher in it than in the larger one which is united to it, on account of the force of attraction which solid bodies exercise on fluids, according to the well-known laws of capillary attraction. Loose earth acts in the same manner as the capillary tubes. In order to become convinced of this fact, it is only necessary to place a pot full of earth, in the bottom of which several holes have been bored, in a vessel containing water, and it will soon become apparent that the water has arisen in the earth to an elevation considerably above the level of the water.

Soils are generally formed of layers of earth and of stone, some of which are porous, and permit the water to pass through and unite with them; while others are impermeable. Mould, turf, sand, gravel, pulverulent lime or chalk, all stones having a porous tissue, schists and rocks containing fissures, are permeable bodies; while dense rocks, various kinds of fossils, tenacious clay, &c., are impermeable bodies, which oppose an obstacle to the passage of water, and retain it. When these latter become indurated and compact, and are saturated with water on their surface, they do not suffer it to percolate or escape, but resist it the same as metal or hard wood. Mixed soils absorb and allow the passage of water in

proportion to their combinations and their degree of porosity. All the fluid which we find on the surface of the soil is occasioned by these alternating and interrupted strata, by those various stratifications, and the furrows and canals which penetrate our soil to unknown depths. If the permeable layers were uninterrupted, the water would gradually sink nearer to the center of the globe; and thus rivers and even the sea itself would finally disappear. If, on the other hand, the whole surface of our earth were formed of one uniform impermeable layer, all moisture would flow to the sea directly it had fallen from the atmosphere, and there would be neither springs, rivers, or fountains. But impermeable strata are intermingled with others that are permeable, in the same way that the human body is intersected with veins. There are but few places where water may not be found, although it frequently exists at a great depth below the surface.

In permeable bodies the water penetrates as deeply, and extends itself at the sides as far as possible; that is to say, until it encounters some impermeable stratum which impedes its progress. Thus, a permeable soil which rests upon an impermeable layer, and is surrounded on all sides to a certain hight by a stratum which will not admit the passage of moisture, must inevitably form a reservoir of water, and have all its pores thoroughly saturated with that fluid; it continues to absorb water until this is the case, and then the fluid regurgitates back to the surface, renders the adjacent land moist; and in wet seasons, when a larger quantity of rain falls than the reservoir is capable of containing in addition to the moisture already assembled there, it necessarily overflows and the water spreads itself over the surrounding land. If the boundaries of this porous earth are of an equal hight all round, and the bottom perfectly horizontal, the superabundant moisture rises equally on all sides; but as this is seldom the case, it generally runs off on that side on which the boundaries are lowest. Sometimes the outlet through which it passes is very narrow, and may be compared to a small piece broken out of a basin, or to the opening through which a brook emanates from a lake. By means of this outlet, the reservoir throws off its superabundant moisture; at least, so long as the quantity of fluid produced by rain or other causes, and the continuous amount of pressure, be not so great as to render it insufficient for the purpose; whenever the latter is the case, the water rises much higher than it would otherwise do, and floods all the lower ground in its neighborhood.

The result is always the same whether these reservoirs exist on the surface of the soil and present themselves to our view under the form of ponds, lakes, &c., or whether they are situated at a greater depth, and covered by a tolerably thick layer of earth. It is likewise immaterial whether they or their openings are formed by empty spaces containing nothing but water, or are filled with earth and porous stones which receive the fluid into their pores and clefts, and suffer it to pass through. The only difference is that the latter imbibe a smaller quantity of water, and do not suffer it to flow so freely, and that this water does not become mingled with anything, but merely occupies the vacant space. The effect of pressure, however, and the addition from above of more moisture, will eventually of necessity cause the reservoir to overflow. Thus, when a reservoir situated in an elevated position communicates with one lower down by means of an open passage, or, what amounts to the same, by means of a layer of permeable earth, the latter will receive the pressure and the superabundant moisture of the former until such time as the water in both forms a level, or, in other words, a horizontal line similar to that which it takes up two in tubes placed vertically, the lower ends of which communicate with one another.

Although these facts are universally known, I deem it right to recapitulate them here in order to be able to make myself understood in the succeeding paragraphs without running the risk of being too prolix.

I must now go on to speak of those considerations and precautions by which we must be governed in all our endeavors to drain land and free it from its superabundant moisture.

The first thing to be done is to find a level, that is say, to ascertain the hight of the point at which that water which we wish to get rid of is situated; also, that of the place to which we would convey it, and of all the intermediate points through which it must pass. The art of leveling and the use of the draining auger will be found applicable to this operation.

Drains, ditches, or gutters are usually formed for the express purpose of carrying off any superabundauce of moisture which may exist in the land.

These may be divided into two classes, according to the purpose for which they are formed:

1. Drains, ditches, or gutters, to collect water.
2. Gutters or trenches which are intended for the pufpose of draining land, and rendering it healthy by freeing it from moisture.

The former, by means of which the water is collected which flows from elevated spots, and prevented from overflowing the plains beneath, ought to intersect the declivity of land. In general, they should be perfectly horizontal at their base, and should have what is called a dead level. It is, however, necessary that the horizontal line which forms the bottom of the ditch should be a little deeper than the layer of earth on which the moisture which we wish to carry off rests or flows.

Drains or gutters for the purpose of carrying off water, whether intended at once to get rid of the moisture which rises in the ground, or as canals to carry off the water collected by ditches of the first class, ought to receive an inclination toward the bottom of the declivity, and to have some slope. But in the greater number of cases this slope must be very gradual, an inch in twenty perches is admitted to be the general average. It is often imperatively necessary to avoid giving a greater degree of inclination to them, lest the bottom should be injured by the too rapid course of the water; and it is sometimes even necessary that their strength should be increased, in order that the slope may be rendered more gentle.

When such a drain or gutter is to be dug, the first thing to be determined is its depth, and the width of the lowest part of it, or that on which the water rests. The depth below the surface of the soil to which it is to be hollowed must be determined in different places by leveling, and its breadth be made proportionate to the quantity of water which may be expected to pass through it. As these ditches must sometimes be horizontal, and at others receive a gentle slope, according as the surface through which they have to pass rises or inclines, they are made deeper or more shallow according to the undulations of the soil. The width of the top of the ditch must be regulated by that of its base, and by its depth, in order that the sides may always have a proper talus. When the land is of a firm and solid nature, the following is the proportion usually adopted: the summit or top of the ditch is made half as wide again, in proportion to its hight, as the bottom. Thus, if it is three feet deep, and two feet wide at the bottom, it ought to measure $3+3+2=8$ at the top. If the surface through which it passes rises a foot, the width of the top of the ditch must be increased to ten feet, and if it rises two feet to twelve feet, in order that the sides may maintain an uniform degree of inclination or slope, and form with the base an obtuse angle of one hundred and thirty-five degrees. In sandy or marly soils, which possess but little solidity and adherence, this inclination is frequently not sufficient, and the top of the ditch has to be made one-half or one-third wider; it is not uncommon for it to be necessary to give a perfectly rounded form to drains or ditches, the profile of which is similar to that of an inverted bow, and in this case grass is suffered to grow on them, so that they furnish fodder for cattle.

The digging and forming of these ditches or gutters is usually performed as task work, and the price regulated by the cubic measure of earth removed; but the operation is rendered more or less difficult by the nature of the soil on which it has to be performed. When the ground is lignt and sandy, the digging up of a surface of one hundred and forty-four Rhenish feet to the depth of a foot will not generally cost more than three groschen; but, if the soil is very argillaceous and tenacious, the expense will be increased to double that sum: on average soils it will be proportionate to the degree of their tenacity. The expense of the operation depends, however, in a great measure on the depth to which it has to be carried; for, as the extraction of the earth becomes more and more difficult in proportion to the depth from which it has to be raised, so must the wages of the workmen be increased in exact ratio with the depth to which they have to dig, otherwise they will gain nothing by the job.

While digging these ditches, it is highly requisite that care should be taken to throw the earth sufficiently far, not only to prevent it from bearing an undue degree of pressure on the edges, but likewise to prevent it from being in the way,

and having to be removed again should it be necessary, as it frequently is, to enlarge and widen the drain.

I must here observe that it is not sufficient to trace out and dig a ditch or gutter, but it must also be kept clear and in good repair; consequently, in forming an estimate of the expenses attending it, those of keeping it in order as well as establishing it must be calculated; and these will be found to vary in different localities, and under different circumstances.

I shall proceed to speak of aqueducts and subterraneous drains by and bye.—Previously to undertaking any operations for the purpose of freeing a soil from its superabundant humidity, we must, in the first place, endeavor to ascertain precisely from what cause this humidity arises, in order to be enabled at once to adopt the most efficacious means of remedying the evil, and those best adapted to the locality.

The causes generally productive of superabundant moisture may be classed under the four following heads; or, in other words, the evil may arise—

(*a*). *From rain water or other moisture deposited by the atmosphere on a spot where, from the retentive nature of the materials of which the surface is composed and the strata on which it rests, this fluid cannot penetrate deeper or flow onward.*

(*b*). *From water which flows from higher grounds, and which is retained on the surface of the soil by inequalities or elevations, which force it to remain in that place until it evaporates.*

(*c*). *From water which flows from elevated regions, and descends for a considerable distance among the porous substances between the different strata of clay before it shows itself, or breaks out on the surface of the ground, beneath which it often forms actual springs which have no means of escaping.*

(*d*). *From water-courses, which occasionally or permanently cover the surrounding land with water, either by overflowing it, or gradually trickling over and saturating it; or which, by the elevation of their bed and of their general surface, prevent that moisture which descends from the hights, and is collected on the plains, from draining away and escaping.*

(*a*). The moisture which falls immediately from the atmosphere becomes injurious when deposited in too large quantities, or in places whence it cannot escape.

If the layer of vegetable earth is composed of clay or lime, or is of a highly tenacious nature, its surface only is plowed; and that very superficially, on account of the difficulty which there is in tilling soils of this nature. The under layer thus becomes formed into a hard crust, which retains all that exists beneath it, and prevents the passage of any from above; consequently, the surface becomes thoroughly saturated, and during heavy rains, or excess of moisture from any other cause, is transformed into a paste, in which state it is exceedingly injurious to plants, and speedily causes their roots to rot, and themselves, consequently, to perish.

These are not the cases in which under or covered drains are likely to prove beneficial; for, as these latter are covered over with earth at least nine or ten inches thick, the water cannot penetrate through this hard layer into them. Wherever proper attention has not been paid to this point, under drains have been found altogether useless; or, at any rate, their utility has lasted but for a very short period; for the earth with which they were covered, although loose and porous at first, is not long in becoming hardened, indurated, and forming an impermeable mass above them.

In order to ensure to a field those advantages which subterraneous or under drains are capable of communicating, it must, previously to their formation, be plowed deeply, and several ameliorations of dung bestowed upon it, in order thoroughly to loosen the soil and render it permeable, at least to a depth equal to that which is to cover the drains.

In most cases, open drains or gutters are in general preferable to subterranean ones. Sometimes recourse is had to these open trenches for the purpose of draining an even soil, and then they are made in that direction in which the declivity of the land is most perceptible; or, in other words, in that which is most likely to carry off the water soonest and best. At other times, the land is divided into beds, slightly raised, elevated, and separated from one another by deep furrows, for the purpose of carrying off the water, which latter are carefully kept clear and open.—Besides this, when occasion requires it, these furrows are connected with transverse drains, which intersect the beds or ridges, prevent the water from stagnating, and carry it off to ditches, brooks, or ponds, where it can do no harm. When the fields are left flat, it is highly important that the drainage furrows should receive such a distribution, direction, and slope, as will best render them useful. It is by no means beneficial to make too many of them: first, because more labor will be thus occasioned; secondly, because they would occupy too much space; and, thirdly, because when they do not contain water enough to enable it fully to clear its way, they are injurious rather than beneficial; and, lastly, because they create inequalities in the soil. When these drains or gutters proceed from low ground, and have to be carried across elevated spots, they produce an effect diametrically opposite to that which is expected of them, and only serve as conduits to convey stagnant water back to the very places they were intended to drain. In such cases as these, the best way is to dig a trench about the elevated places which surround the low land, and

thus intercept that moisture which would otherwise run down on to the latter, and carry it off before it proceeds beyond its proper limits. Too sudden and abrupt a declivity is as much to be avoided as a want of sufficient slope; because, in the former case, when heavy rains fall, the water is apt to rush down with such rapidity as to carry away the soil with it, and thus create embankments at the foot of the hill. Under circumstances of this nature, a circuitous direction should be given to the drains, in order to render the slope more gentle, and suffer the water to drain away without doing any mischief. In general, in proportion as there is difficulty in draining a field, and as its tillage requires tact, skill, and science, in like proportion do we find absurd and ill-conducted operations. Many agriculturists think to show their skill and industry by intersecting their land in every direction with drains or gutters, for the purpose of carrying off moisture, until it almost resembles the model of a seat of war, surrounded by numerous fortifications in a state of progress; but this excess of drainage is not only useless, but is productive of serious evils.

A plow is frequently made use of for the purpose of forming these furrows or drains; and one having two mould-boards is usually selected for the purpose, which, as it completes the furrow at once, admits of one being made as it passes up the field and another as it returns. There are plows constructed expressly for this purpose. The foremost part of the share of these instruments is made in the form of a wedge, while the hinder part has a quadrangular shape; they are provided with two raised mould-boards, one on each side. These plows form a rectangular furrow, and the two mould-boards raise the earth extracted from beneath, and spread it on the edges at either side, so that it shall not fall back again into the furrow. But when it becomes necessary to make the drainage furrows of some considerable depth, these implements encounter great resistance, require great draught power; and as the bottom of the furrow which they trace is always parallel with the surface of the soil, they become useless when they have to traverse an undulating or rugged surface, because the course of the water would be impeded if the elevations left by the plow in the furrow were not got rid of with a spade. Our plow, with two movable mould-boards, is best adapted for the purpose of forming these drains. This instrument is more manageable, and can be made to penetrate deeper into the soil at will. At first, the mould-boards are only opened a little way, but subsequently, when the plow is introduced into the soil a second time, at those places where the elevations of the ground exist, the instrument is made to penetrate farther, in order that by a uniform slope being given to the bottom of the drainage furrow, the water may be properly carried off. This instrument forms an angular furrow at the bottom; while its sides, having a due degree of inclination given to them at first, seldom require to be touched by the spade. No time must, however, be lost in leveling the earth thrown up by the mould-board on the edges of the furrow, especially if the furrow has been formed subsequently to the sowings, otherwise there will be danger of the seed being smothered under these heaps of earth. This operation can easily be performed by means of a rake.

Many agriculturists prefer having these furrows formed by spade labor.

In whatever manner they may be made, they must be carefully attended to, and occasionally repaired and cleaned out, especially at those periods when heavy falls of snow melt, because it is impossible to foresee the causes which may tend to obstruct, choke, or fill them with sand.

It cannot, however, be denied, that too great a number of these drains or gutters are apt to leave slight inequalities in the land which can never be entirely got rid of. When the soil is of a tenacious nature, these inequalities are injurious, and in some places even tend to impede the operation of sowing. This consideration leads me to give the preference to the formation of large and slightly elevated beds and ridges on flat even soils which possess but little slope, particularly if such a direction can be given to these ridges as will cause the water to drain off easily through the furrows or trenches by which they are separated But I should not advise that, on a width of from two to three perches, the center of these ridges should be raised more than six or eight inches higher than the sides of the trenches. Great care must be taken to prevent the earth from being heaped up at the sides; and in plowing the ridges, the curve or elevation must be extended in an almost insensible manner over the whole of the ridge. As in this case the trenches will always be formed in the same spot, especially when the ground is prepared for autumnal corn, their direction must be carefully determined so that it may accord with the declivity; and all things so arranged that no hollow shall remain on the ridges;.at any rate, none below the level of the trenches. The latter must be carefully finished off, and always kept clear and open, so that the water may pass freely through them. They should be brought into communication with each other by means of cross open drains. But in order to render these drains perfectly efficient, a canal or ditch for the reception of the water which they collect, and toward which they should all slope, is absolutely requisite at the bottom of the enclosure. Where this advantage is unattainable, a ditch or main drain must be dug in the lowest and dampest part of the field, for the reception of the water, and thus a portion of the ground sacrificed in order to save the rest.

It very often happens, that although the layer of vegetable mould is sufficiently loose and porous readily to allow moisture to sink into and filtrate through it, there is beneath it an impermeable, retentive layer of clay, which prevents the water from passing. When the layer of vegetable earth is thick, it is better capable of bearing heavy rains, because there is then more room for the water, and, consequently, it does not flow back to the surface so soon; but when the quantity of water becomes so great as to render it impossible for it to be contained in the interstices of the soil which constitutes the vegetable layer, the land suffers from excess of moisture for a considerable period. This superabundance of humidity is longer in evaporating in proportion to the thickness of the layer of earth which is saturated with it.

We spoke of the means of deepening the layer of vegetable soil while treating of the subject of plowing.

The thicker this cultivated layer of the soil, the deeper must be the drains or furrows made for the purpose of carrying off the humidity; for in order that they may produce the desired effect, they must be hollowed out to the impermeable layer. If care has not been taken to make them sufficiently deep to reach this level, the water, instead of being carried off, sinks through the per-

meable earth at the bottom; therefore, even though constructed in the direction of the declivity, they will be productive of little or no effect, since at most they would only carry off the overflowings of the water, while the remainder will sink into the permeable soil beneath, and render the bottom of the soil prejudicially wet.

These trenches must, therefore, be horizontal, and intersect the declivity, in order to cut off the water and conduct it into the drain which is to carry it off. Should the sides and bottom of them not be made sufficiently compact to prevent the water from filtering through, it will penetrate into the soil, and, according to the laws of gravity, extend itself over a fresh portion of the field until taken up by some other drain or furrow.

Such deep trenches are attended with great inconveniences. They are destroyed by each plowing; and, consequently, when the land can only be preserved from excessive humidity by their means, require to be as often reconstructed. It must be confessed that this is seldom done on account of the labor that would be thereby entailed, and the great expense arising from the performance of the operation, and from that of spreading over the ground the quantity of earth which has been thrown up while forming the trench. Besides, there will always remain perceptible hollows in those places where the drains previously existed; and if the new ones are not traced exactly in the same spot occupied by the others, these hollows will become receptacles for standing water, which will essentially injure the crops. This will invariably occur after the melting of heavy falls of snow. When the snow melts rapidly, or heavy storms of rain fall, whatever care may have been bestowed on the formation of these deep drainage furrows, the water will frequently overflow and carry away with it portions of the surrounding soil; therefore, in cases where drains are absolutely indispensable, it will be best to form subterranean or covered drains; and it not unfrequently happens, that the expenses attendant on their formation are amply repaid in the course of one or two years after their construction in a cold, wet soil. If these drains are properly arranged, the field may be left perfectly flat, and plowed alternately in all directions, and at almost all times and seasons, without suffering from excess of humidity.

There are two points which must be attended to in the making of under-drains. If the land has any degree of declivity, they must, in order to be productive of the required effect, be made in a contrary direction to it, and intersect or cross the slope, otherwise they will not be able to collect all the water which is contained in the soil. When formed in this transverse direction, a slight degree of inclination toward the ditch which is to receive and carry off the water, must be given to them; but this must never go beyond an inch in ten perches. It is, of course, understood, that it must be guided by the horizontal basis of the soil, and not by the surface, which is often unequal.

The best way of managing these subterraneous drains, is to make them open into a ditch or conducting drain which is to carry off the water to some river or lake, and to surround the opening with stones to prevent it from falling in or breaking. Sometimes two, three, or more drains are made to meet together, and emit their contents through one opening; but this is a mode of proceeding by no means to be recommended, because one or the other will very frequently be choked up, and it will then be difficult to discover which one is at fault.

These drains or gutters are made of various depth. If an impermeable stratum is found existing beneath a layer of porous earth, it is necessary to dig on until we come to the latter, and there form the canal along which the water is intended to pass. If, on the other hand, the layer of argillaceous earth is not very thick, it will be sufficient for the drain to be covered by a foot of earth, or even by ten inches, when the soil at the surface is moderately tenacious; but in cases of this nature the plowings must never be carried beyond a depth of six inches. In light, loose, sandy soils, the drains must be covered with at least eighteen, if not twenty-four inches of earth. This thickness is, however, subject to modification. If the drain has to be carried through a rising ground, a depth of from nine to ten inches is sufficient for that portion of it which is intended to contain the water. It may be made as wide, or a little wider than it is deep; but this will depend, in a great measure, on the nature of the materials with which it is to be filled up. If rough stones gathered from the fields are to be made use of for the purpose, its width at the top should be sixteen, and at the bottom only ten inches; but when it is to be filled up with branches, nine inches will suffice for the width at top, and two or three at bottom.

In digging drains, their opening at the surface of the soil should be made large enough to enable every part of the operation to be conveniently carried on.

In large undertakings, it is customary to make use of a plow for the purpose of commencing the opening of a drain. Two furrow-slices are thrown off by this instrument, the one to the right and the other to the left, and a strip of earth of about fifteen inches wide left between the furrows. This strip is subsequently divided with a strong plow, having a double mould-board. The first time this instrument passes through the soil, it is made to penetrate to the depth of about a foot; and the second time it is so arranged as to turn up the soil to at least six or eight inches lower down. The earth is immediately removed from the sides, lest it should fall back again into the ditch during the operation. The excavation is then continued with manual implements. A common spade is first made use of which is a little narrower at the bottom than it is at the top; and, subsequently, another is had recourse to, the upper part of which is scarcely so wide as the lower part of the former one, and its extremity not more than three inches wide. By digging successively with these two instruments, and exercising a little care and skill, the drain will speedily become properly shaped; the walls must then be united, and all the loose earth which has fallen to the bottom removed thence with a curved shovel. That part of the drain through which the water is to pass must then be lined with stones or with branches, according as one or the other can be procured with the least trouble and expense. If the stones can be obtained from a neighboring field, they are to be preferred. The large and small ones are mixed together; but in placing them in the drain, care must be taken to pile the largest and flattest along the sides. When branches are made use of, they are sometimes tied up in bundles; but it is much better to lay them in one by one, the largest being placed at the bottom, and the smaller ones above.

Experience has proved that light, aquatic wood is better adapted for this purpose, and more durable than hard wood; thus the branches of alders, willows and poplars are preferable to those of firs, the juniper and other resinous trees. It is, however, highly essential that the branches made use of shall have been fresh cut, or, in other words, green and full of sap.

It is generally found that drains lined with branches remain open longer and are more durable than those in which stones have been made use of; even after the wood has rotted, the drain retains its form if the soil be of an argillaceous nature.

The stones or branches with which the drain is filled must be covered up with straw, furze, rushes, or similar material, in order to prevent the earth from sinking in between the interstices; or they may be simply covered with the turfs raised from the surface of the ditch, turned bottom upward, and pressed down with the feet to render them solid.

When the trench comes to be covered up, care must be taken neither to put very loose earth above it, which might sink in and fill up the interstices through which it is intended the water should pass, nor yet tenacious clay, which would soon adhere so firmly together as altogether to prevent the filtration of water through it. The soil immediately over the trench ought to be left a little higher than any of the other parts, because it invariably sinks down and diminishes.

When the soil is of a highly argillaceous nature the drains are seldom made very wide, and are filled up with straw twisted into the form of ropes; sometimes they are left empty and simply covered with turfs: the clay soon gets so firm and hard that a crust is formed all round the drain, and the lower part remains open long after the straw has rotted away.

In some places, instruments termed mole-plows are introduced into the soil, the effect produced by which is highly satisfactory.

In loose, sandy, and peaty soils, bricks made for the express purpose, and other inventions of art, are employed in sustaining the walls of drains, and sometimes the gutters are left entirely open.* Trenches for the purpose of draining land must be placed nearer together or at a greater distance from one another, according to the degree of humidity of the field or meadow which they are intended to dry. The usual intervening space is from three to four perches. When the soil is of a highly argillaceous nature, and covered only with a very thin layer of vegetable mould, they must be brought nearer together.

Whenever the requisite materials for filling up the drains are procurable on the estate, the expenses of the operation of draining are trifling in comparison to the advantage the soil derives from it. In England this operation is very frequently undertaken by farmers who only hold their land on short leases, and yet they find that the outlay is amply repaid by the increase of fertility produced, and the consequent increase in the produce of the soil. This operation cost one of my friends who was advised by me to undertake it, and whom I directed how to proceed, one rix-dollar and sixteen groschen per acre, and the next year the produce of his wheat crop was increased two bushels and a half.

One necessary precaution which must never be lost sight of, is that of not allowing heavily laden wagons to traverse the ground thus drained in the direction of the drains.†

(*b*). The second cause of excessive humidity is generally to be met with in valleys surrounded by hills, from which the water runs down and sinks into the land, or unites and settles on the surface in the form of ponds or stagnant marshes, without finding any outlet, and is, consequently, obliged to remain there until evaporated. When the soil of such valleys is not of a porous nature, and no drains have been formed in it, they of necessity become marshy, saturated with water, and often transformed into lakes or bogs. It is in general exceedingly difficult effectually to remedy matters when they have come to this state; but when taken in time there are many cases on record proving the immense advantages resulting from drainage, and in which the benefits derived have amply repaid the expenses: and this has been especially the case where it has only been requisite to choose the lowest part of the rising ground by which the valley is surrounded; or if there be such, some place hollowed out by the moisture, and there form a ditch of sufficient depth to carry off the water to the lowest spot, and thence to some river or lake. Previously to commencing such an operation, it is best carefully to calculate the expenses and outlay which it will occasion; and after comparing these with the advantages which may be derived from it, to decide accordingly.

Sometimes it is impossible to carry off the water to the lowest part of the valley, because there is not sufficient declivity there to admit of a course being formed for it. When once it has been clearly ascertained that these waters flow from the rising grounds, it may, in some cases, be advisable to intersect the declivity by a canal, or canals, for the purpose of collecting them. This canal ought to be situated at such a hight as will admit of its being emptied from below, or by means of outlets carried across the lowest part of the rising grounds which enclose the valley: by this means a great portion, if not the whole, of the moisture will be got rid of. There is also a third means of remedying this evil, and it may be had recourse to when a layer of gravel or permeable sand exists beneath a thin bed of impenetrable soil. In this case one or more ditches may be dug through the impermeable layer, or wells sunk, or holes bored in the ground with a large draining auger, through which the water may filtrate into the porous stratum: this mode of proceeding has often been found sufficient to drain marshes, fens, and even lakes, and render the spots formerly occupied by them fertile land. But prior to the undertaking of such operations the chances of success should be carefully calculated; and we must ascertain whether or not when the water has reached this sandy or porous stratum it will be able to force a passage for itself; or whether the sand may not already be so completely saturated with moisture as to be unable to contain more, as is very frequently the case when the layer of it communicates with the

* See a work by this author, entitled "Anleitung zur Englischen Landwirthschaft," vol. ii. part 1, page 50; and also Count Podeivel's translation of "Johnston uber Anstrocknung nach Elkington."—Berlin, 1789.

† The German farmer evidently fell into the error, too common in England, that of placing their under-drain not sufficiently deep in the soil.

surrounding hights. Under such circumstances the addition of fresh moisture will only tend to cause the water to rise up through the newly formed aperture, and flood the land which we desire to drain.

These evils may in some degree be remedied in fields exposed to them by intersecting the ground with numerous ditches, and raising its surface by the addition of the earth taken from these, or by supplies of sand brought from some of the neighboring hights. The great fertility of the soil of valleys will often amply repay the outlay required for such an amelioration.

(c). In by far the greater number of cases, springs are formed in the following manner:—The moisture of the atmosphere being condensed in much larger quantities on the summits of mountains and in elevated situations, the water thus formed as well as that which falls in rain, sinks according to the laws of gravity perpendicularly through the superficial porous earth until its descent is retarded or totally obstructed by an impenetrable substance; it then becomes dammed up, and is ultimately forced to filtrate slowly over this layer, or open for itself an outlet at the spot where this bed rises to the surface of the soil. Should it not find any channel here, it gushes forth in the form of a spring; if there is sufficient slope, it hollows a bed for itself, and descends over the lower ground in the form of a brook, without, however, making the adjacent soil damp. But when a quantity of porous earth is collected at the place where the impenetrable bed finishes on the declivity or at the bottom of the hill, the water sinks into it, renders a large extent of ground damp and marshy; and being forced onward by the pressure which it receives from above, opens for itself passages, reäppears on the surface, and forms bogs and fens, or trickles over the surface.

This is one of the most frequent causes of humidity and of the formation of marshes or bogs.

On land of such a nature, recourse is frequently had to means which, although very expensive, are altogether fruitless, or at any rate productive of but little effect. A number of drains are dug, which only dry the land close to their edges; and, even when the most favorable direction is given to them, will, if not hollowed out to the impermeable layer, suffer the water to sink through them into the earth beneath, and thus become entirely useless. It is impossible that drains can ever be efficacious unless the bottom of them rests upon an impenetrable stratum; where such is not to be easily met with, they must be carried to a very great depth. It is, therefore, of the utmost importance that we should be enabled at once to distinguish the causes of the various kinds of humidity that are met with; and if proper attention is paid to the position of the divers strata of earth which give rise to the springs which we wish to get rid of, we shall find these causes reduced to a very small number.

On the slope, or at the foot of hills, the water does not usually flow directly over the horizontal or inclined layer of impermeable soil which prevents it from sinking into the ground. At the lower part of all hills, even such as are chiefly composed of stones and gravel, a primary layer of argillaceous earth is found; which, in general, gradually becomes thinner as it approaches the summit of the hill, and thicker toward the foot. In all probability, among other causes, this layer owes its formation principally to the particles of clay which the water has washed away from the higher ground, which it carries with it, and gradually deposits during its progress. The base of hills and mountains is generally found to be surrounded by a bed of argillaceous clay of greater or less depth. Thus we see that the water which sinks into the porous earth becomes enclosed between the impermeable layer and this primary stratum of clay, and a reservoir is formed which encloses more or less fluid, according to the quantity which falls from the atmosphere. This fluid escapes at the termination of the upper impermeable stratum, or else forces its way out wherever it is thinnest. In such cases as these, it does not present itself on the surface at once, because in general there is a bed of earth of that spongy, marshy nature, which is produced by excessive moisture, collected above the upper impenetrable layer. The water which escapes from beneath this latter saturates the porous bed, and renders a greater or less extent of ground wet and swampy, and thus forms bogs or fens.

The spring, properly speaking, or the place where the water gushes out from the clayey layer, is often higher up than the spot where the moisture begins to show itself on the surface of the soil; for when the bed of porous earth is tolerably large and the declivity rapid, the water sinks through, flows over the impermeable stratum, and does not show itself on the surface of the ground at all, at least during dry weather. Indeed, it seldom betrays itself until it reaches the bottom of the hill where the declivity ceases, unless it encounters elevations in the stratum of clay which impede its progress and force it up to the surface, or unless the bed of porous earth becomes very thin.—These circumstances will occasionally cause the land to become wet, and to be injured by excess of moisture, even near the summits of mountains.

When, in digging a drain, the workmen come to the upper clay stratum, they should either make hollows in the bottom of the trench with a spade, or else bore holes in it with a boring auger, which shall perforate the bed of clay and penetrate into the sandy or gravelly reservoir, so as to give free vent to the water, which then gushes out through these holes with considerable impetuosity, and flowing along the drain, runs off into the connecting ditches prepared for its reception, and thence into some neighboring river or brook. It will be understood that, in order thoroughly to produce this effect, the bottom of the drain must be higher than the level of the country below. Elkington made this discovery quite accidentally. He was standing upright in a ditch which he had caused to be dug for the purpose of draining the surrounding land, and which had turned out totally inefficacious, and in his vexation he struck the ground with an iron bar which he happened to have in his hand; this pierced through the layer of clay, which had previously been rendered thin by the excavation of the ditch; in an instant water gushed through the hole thus made with such force and rapidity as to compel him to retreat precipitately from the ditch. When he saw the effect produced, he made other holes with a boring auger, and by this means soon dried all the surrounding land. Subsequently, he effected the drainage of a number of spots where the performance of the operation with any degree of success had long been deemed hopeless, and thus acquired great celebrity. In digging drains, cases of this description very frequently present

themselves; there are few workmen accustomed to this kind of labor who have not more than once seen the water rise thus from a bed of clay at the bottom of the trench.

By means of these drains, and of holes thus bored in the bottom of them with boring augers, an outlet may be made even in the lowest situations for the water collected in the beds of gravel, sand, or stones, which exist in the inferior part of the soil; and as almost all the reservoirs of water communicate with each other by means of the porous beds and veins contained in the ground, the whole of the moist land will thus be freed from its superabundant moisture.

By means of a drain thus pierced with holes at the bottom, all the land above the level for a considerable extent may thus be freed from moisture; that is, supposing the reservoir containing the water is reached: and thus all those springs which show themselves on the hights will be got rid of, provided that they communicate with one another by means of those veins or beds of porous earth I have already spoken of, as is usually the case. I have known instances in which, when this operation has been performed on one side of a hill, its effects have extended to the other, and drained it so completely as to cause a scarcity of water, while the drain has been so full as to contain water enough to turn a mill. Sometimes the water thus obtained may be employed with advantage in the irrigation of the same ground, which, having been thus freed from its superabundant moisture, may be transformed into watered meadows of good quality.

The holes formed by the auger do not easily become closed up; on the contrary, they are enlarged by the action of the water, and thus become artificial springs. A greater or less number of them must be bored, according to the quantity of water which will have to pass through. It is, however, as well to surround them with masonry, in order that, if the sides of the ditch should fall in, they may not be stopped up. This operation, it must be remembered, will not effect the drainage of any land below the level of the ditch.

I trust that I have been enabled to give a clear insight into the course which must be pursued, both for the purpose of collecting the water of these springs, and draining the land which they render wet. The principle of action is in itself very simple, but in order to put it in practice, a perfect acquaintance with all the circumstances of the locality, and a careful survey of the country, are requisite, as well as thorough and distinct notions of the various strata of which the soil is composed; and this not merely with regard to its surface, but extending also to its utmost depths. The nature and position of the different strata are sometimes accidentally discovered by noticing places in the vicinity of drains where the earth has fallen down; but this point can be much better ascertained with the assistance of the boring auger.*

(*d*). In order to prevent the overflowing of water-courses and rivers beyond their proper beds, and to diminish these beds when they are too large, recourse is had to the construction of *dams* and *banks*.

Notwithstanding the efforts of those talented theoretical and practical men who have turned their attention to the difficult and complicated art of constructing such banks or dams as shall be firm and durable, both the principles and application of this branch of science are yet, if not in their infancy, at least very undetermined. The forming and maintaining of high and extensive banks, as well as all matters relating to their execution and direction, is seldom undertaken by private individuals, but is usually a public concern, and is confided to the, superintendence of skillful engineers, and men who are experienced in operations of this nature. Nevertheless, it may be interesting to agriculturists who reside near such places to acquire some degree of fundamental knowledge with regard to this subject, and read some of the works that treat of it.†

By means of banks or dams land is protected from the effects which might result from an excessive swelling of rivers, or from their subsequent overflowing, and land rendered capable of receiving cultivation which had previously been covered with water.

The means of constructing banks which are perfectly solid and durable is now well known.—But time alone and the most frightful calamities led to the discovery of the principles, without which the requisite degree of solidity could not be given them. Houses may now be built close by these dams or banks, without any fear or danger of their suffering from those accidents which are so frequent in our climate, and under our temperature; and which, in the vicinity of imperfectly formed banks, render constant and unremitted attention necessary whenever the water rises above its usual level. But even now, in the present advanced state of the science, these banks or dams are only capable of ensuring protection from those inundations which may be caused by the reflux of the sea and the action of the waves, the force and volume of which theory and practice enable us to calculate: but they are incapable of securing land from floods caused by excessive swelling of the river, arising from the thawing masses of ice, because in this case it is impossible to calculate the volume or force of the power which the banks will have to contend against. In the latter case there is doubtless much to be feared; but when a large piece of land is left between the bank and the course of the river, and the current or course of the latter is made perfectly straight, or suffered to wind a little, these dispositions will afford more safety than the strongest or highest banks.

* There is in Germany a translation of Johnston's work by the Count de Podelvels, entitled "A Treatise on the draining of marshes and cold, wet lands, according to the method discovered by Elkington." It was published at Berlin in 1799. In this work the subject which I have been endeavoring to explain, is entered into at great length, but in a very incomplete and confused manner. But with the assistance of what I have said above, a clear notion may be formed of all the cases mentioned there.

† "Hunrich's Praktische Anleitung zum Deich, Siel, und Schleusenbau." Bremmen, 2 Theile, 1770, 1782. "Kinchmann's Anleitung zum Deich, Schleusen, und Staatbaukunst." Hanover, 1786. "Riedel's Anleitung zur Strom und Deichbaukunde.' Berlin, 1800.

Unfortunately, in the formation of banks or dams, it too often happens that the work is performed in a great hurry, and sufficient care is not taken to see that the earth is made firm and solid; or the extent of space allowed for the passage of the water is too much confined, in order that more ground may be left for cultivation. From this carelessness and false economy, accidents and losses arise which greatly overbalance the value of the saving which is aimed at.

Even when these banks or dams are capable of preserving the land from being inundated or flooded, the soil is not freed by them from its superabundant moisture. The water which descends from the high ground to mingle with the water of the river must have some means of escape, and be prevented from remaining on the surface, or sinking into and saturating the ground. The means which may be adopted to prevent this are many and various; and we must be guided in our selection of them by the circumstances of the locality. Sometimes it may be carried off into the river by means of canals cut in as direct a line as possible, from which the water passes under the banks through sluices which open to give it passage.

These sluices are in general furnished with a kind of door, which the water in the river closes as it rises, and which is afterward opened by the water in the canal when the former falls again.

By this means, damp, moist lands which are situated pretty high, may in general be easily freed from their superabundant humidity; but not so land which is beneath the level of the bed of the river.

In cases of this nature, various imperfect modes of proceeding are resorted to; for example, the land is surrounded with drains and dykes for the purpose of carrying off the water which falls from the higher ground, and these are connected with canals which are raised above the level of the soil and convey it to the neighboring river.

Occasionally, however, when the water cannot be kept sufficiently elevated, pumps or drawing machines are employed to raise it from the bottom of these dykes or trenches. But it must be borne in mind that ditches of this kind can only prove beneficial where the soil is of an argillaceous nature, and is tolerably solid. In light, porous land they would be perfectly useless.

We can only reckon with some degree of certainty on success when, by means of a drain of sufficient dimensions we can cut off the water which descends from the hill in some spot above the level of the river, and high enough to enable us to direct this water into the stream which is to carry it off. If a drain of this kind has sufficient declivity, there is not a doubt of its proving beneficial; but it not unfrequently happens that mounds of sand are formed in its bed which obstruct the passage of the water, destroy the declivity, and, consequently, cause it to overflow, and thus transform land which was completely drained, into a bog.

It now and then happens that a third mode of proceeding may be adopted, namely, that of constructing dykes formed of solid earth all round the land, and emptying out the water from them with machines for drawing or pumping up water.

There are various kinds of these machines; but the greater part of them are worked by means of sails similar to those of a windmill. The inhabitants of Holland have surpassed those of all other countries in inventions of this nature. The most essential quality of this kind of machine consists in its requiring no other agent than wind to put it in motion, and being constructed in such a manner as not easily to admit of its being injured or put out of order; should such not be the case, it will be liable to become unfit for use at the very moment when most required. On this account those which require great motive power are very complicated, and, containing a great deal of iron-work, are always exceedingly troublesome. The "*drawing-wheel*," the "*throwing-wheel*," and "*Archimedes' screw*," are, when well constructed, fully capable of effecting the purpose for which they are designed; but the "*hydraulic ram*," a newly-invented instrument, is only adapted to particular situations. The "*Montgolfier*" machine, which has latterly so greatly attracted the attention of mathematicians and natural philosophers, is wholly inefficacious. Latterly, steam-engines have been made use of for this purpose with great success; but it must be admitted that they are very expensive.

It not unfrequently happens that it becomes necessary to make use of several of these instruments at once, in order to raise the water to the requisite hight.

The same means which are resorted to in low situations, protected by banks or dams, for collecting and carrying off the water which falls from the hight, may, with very trifling modifications, also be used to get rid of that which oozes or transudes through the earth, as standing water or fens. This moisture is occasioned by the water situated in the hights, which filters through the porous layers and veins of soil, and collects on the low, flat land. When rivers overflow, the moisture thus produced in the land is not easily got rid of, even after the flood has subsided; on the contrary, it appears as if it was then only that the ground becomes thoroughly saturated. It often happens that the water does not ebb back to the surface until the river has resumed its usual position. This is one reason why these waters may not only be got rid of by means of canals which pass under the bank or dams, and have gates or sluices which open when the river is low from the effect of the pressure of the water in the canal, but also by dykes dug in an oblique direction relatively to the course of the river, in order that they may unite with the latter at the spot where the water in them has attained an equal level, or is a little higher than that in the canal.

When excessive moisture is occasioned not by standing or subterraneous water, but by the overflowing and oozing out of rivers, which, on account of their serpentine course, have not sufficient declivity, the best thing that can be done is to alter and improve the direction of the bed of the river, and remove all those obstacles which impede the passage of the water. The straighter its course, the more rapid will be the current; and the more rapid the current, the less considerable will be the volume of water resting on any portion of the bed at once. The fewer obstacles it encounters, the more gently will it flow onward; and the more gently it flows, the less damage it is likely to do. The alteration may be effected in two ways. In the first of these, the windings of the river are cut through and its bed altered; and thus it is frequently materially shortened, rendered more sloping, and consequently flows much more rapidly and gently. In this

manner a considerable extent of fertile soil admirably adapted for wheat or meadow land is often gained, and its produce soon repays the expense and outlay required by this operation. Should this mode of proceeding not appear advisable, a portion of the water in the river may be carried off without altering the former bed; but by digging a canal in the vicinity, which, from being straighter, has a greater degree of declivity. There is no necessity for making this canal very large at first, for the action of the water gradually tends to increase the size of it, until at length it becomes capable of containing and carrying off all the water in the river, and thus renders the previously existing bed entirely useless. This has been the case in the newly formed bed of the Oder, extending from Güstebinse to Niederwutzen.

Meadows situated on the borders of a river or stream that winds considerably, and the water of which rises above the surface of the neighboring land, generally suffer greatly from humidity. This evil may, however, often be remedied by digging a ditch or drain along the meadow, from its upper to its lower part, which drain is made to open into the river at the point where its bed is lower than the surface of the meadow. This drain will speedily carry off the overflowings of the water, especially if its operation is facilitated by the addition of smaller drains leading into this one. The earth which is extracted from this drain will sometimes be sufficient to form a bank along the side of the river, when the distance to which it must be transported for this purpose is not too great.

In countries much intersected with streams and rivers, it very frequently happens that the low grounds in the vicinity of these are so considerably below the level of their beds as to render it impossible to carry off the superabundant water with which such land is saturated by means of the river. In cases of this description, after having enclosed the highest parts of the river with banks or dams, the ground may be drained by means of pipes or tunnels passing through these banks and under the bed of the river; or else by covered drains formed of mortar or masonry, through which the water is carried off to some lower brook. Cretté de Paluel, a most distinguished French agriculturist, made trial of this mode of proceeding in two different places. I shall extract an account of the operations from the "Memoirs of the Agricultural Society of Seine," vol. iv. both because they furnish examples of an operation which occurs but seldom, as well as because these two cases are very instructive, on account of the number, nature, and variety of the circumstances relating to them.

"All this," says Cretté, when speaking of a great extent of drainage which he had successfully accomplished, "have I effected; and any who choose may come and satisfy themselves by seeing it." "There is, however, one rule from which I never depart," he says in another place, viz. "that of conducting all my operations and undertakings on a liberal scale, and never suffering any false notions of economy to mar the whole. The soil amply repays the capital which is bestowed upon it, provided that it is skillfully and judiciously bestowed; but those who act parsimoniously, and grudge every farthing, can never expect to derive any great profits; the enterprising alone will find their endeavors crowned with success: this observation relates particularly to draining."

The Draining of various kinds of Marshes.

We class under the denomination of marshy all those uncultivated lands which are of a spongy nature, and always saturated with water.

They are divided, first, into *green marshes*, *swampy bogs*, or *meadows*: this variety comprises those which are covered with a layer of turf, or of high grass, which finds an abundant supply of nutriment in the upper stratum of the soil. And secondly, into *peat marshes*, *sterile bogs*, or *furze land*, on which nothing but mosses and a few other plants grow, as the yellow star of Bethlehem (*ornithogulum luteum*), marsh ledum (*ledum palustre*), sweet gale or myrrica, common and crop-leaved heath, (*erica vulgaris et tetralix*), &c.

Marshes of the first class, although constantly moist and wet, yield some little hay, but this is in general far from being nutritious; it is unpalatable to cattle, and very often unwholesome; besides, it can only be secured in very dry seasons: cattle cannot be pastured on such land without danger.

Peat marshes yield scarcely any pasturage, and no produce; but the peat which may be obtained from them is very valuable.

Neither of these varieties can be rendered fertile until the soil is thoroughly drained and rendered healthy; and this drainage must be effected by such means as the nature of the circumstances may seem to indicate. Considerable sums are often expended in this operation to little or no purpose, on account of the cause from which the wetness arises not having been clearly ascertained in the first place.

If the superabundant humidity of the soil is caused by the stagnation of water which falls from the neighboring hills and elevations, and settles in the valleys and on the low grounds where it can find no vent, and where an impermeable layer of earth prevents it from penetrating deeper into the soil, the first thing to be ascertained is whether or not a canal, the bottom of which shall be on a level with the marsh, can be dug on the declivity of the neighboring hill. If the expenses attendant on the formation of such a canal do not exceed the profits which may be expected to be derived from the advantages resulting from the drying of

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In cases of this nature, various imperfect modes of proceeding are resorted to; for example, the land is surrounded with drains and dykes for the purpose of carrying off the water which falls from the higher ground, and these are connected with canals which are raised above the level of the soil and convey it to the neighboring river.

Occasionally, however, when the water cannot be kept sufficiently elevated, pumps or drawing machines are employed to raise it from the bottom of these dykes or trenches. But it must be borne in mind that ditches of this kind can only prove beneficial where the soil is of an argillaceous nature, and is tolerably solid. In light, porous land they would be perfectly useless.

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When excessive moisture is occasioned not by standing or subterraneous water, but by the overflowing and oozing out of rivers, which, on account of their serpentine course, have not sufficient declivity, the best thing that can be done is to alter and improve the direction of the bed of the river, and remove all those obstacles which impede the passage of the water. The straighter its course, the more rapid will be the current; and the more rapid the current, the less considerable will be the volume of water resting on any portion of the bed at once. The fewer obstacles it encounters, the more gently will it flow onward; and the more gently it flows, the less damage it is likely to do. The alteration may be effected in two ways. In the first of these, the windings of the river are cut through and its bed altered; and thus it is frequently materially shortened, rendered more sloping, and consequently flows much more rapidly and gently. In this

manner a considerable extent of fertile soil admirably adapted for wheat or meadow land is often gained, and its produce soon repays the expense and outlay required by this operation. Should this mode of proceeding not appear advisable, a portion of the water in the river may be carried off without altering the former bed; but by digging a canal in the vicinity, which, from being straighter, has a greater degree of declivity. There is no necessity for making this canal very large at first, for the action of the water gradually tends to increase the size of it, until at length it becomes capable of containing and carrying off all the water in the river, and thus renders the previously existing bed entirely useless. This has been the case in the newly formed bed of the Oder, extending from Güstebinse to Niederwutzen.

Meadows situated on the borders of a river or stream that winds considerably, and the water of which rises above the surface of the neighboring land, generally suffer greatly from humidity. This evil may, however, often be remedied by digging a ditch or drain along the meadow, from its upper to its lower part, which drain is made to open into the river at the point where its bed is lower than the surface of the meadow. This drain will speedily carry off the overflowings of the water, especially if its operation is facilitated by the addition of smaller drains leading into this one. The earth which is extracted from this drain will sometimes be sufficient to form a bank along the side of the river, when the distance to which it must be transported for this purpose is not too great.

In countries much intersected with streams and rivers, it very frequently happens that the low grounds in the vicinity of these are so considerably below the level of their beds as to render it impossible to carry off the superabundant water with which such land is saturated by means of the river. In cases of this description, after having enclosed the highest parts of the river with banks or dams, the ground may be drained by means of pipes or tunnels passing through these banks and under the bed of the river; or else by covered drains formed of mortar or masonry, through which the water is carried off to some lower brook. Cretté de Paluel, a most distinguished French agriculturist, made trial of this mode of proceeding in two different places. I shall extract an account of the operations from the "Memoirs of the Agricultural Society of Seine," vol. iv. both because they furnish examples of an operation which occurs but seldom, as well as because these two cases are very instructive, on account of the number, nature, and variety of the circumstances relating to them.

"All this," says Cretté, when speaking of a great extent of drainage which he had successfully accomplished, "have I effected; and any who choose may come and satisfy themselves by seeing it." "There is, however, one rule from which I never depart," he says in another place, viz. "that of conducting all my operations and undertakings on a liberal scale, and never suffering any false notions of economy to mar the whole. The soil amply repays the capital which is bestowed upon it, provided that it is skillfully and judiciously bestowed; but those who act parsimoniously, and grudge every farthing, can never expect to derive any great profits; the enterprising alone will find their endeavors crowned with success: this observation relates particularly to draining."

The Draining of various kinds of Marshes.

We class under the denomination of marshy all those uncultivated lands which are of a spongy nature, and always saturated with water.

They are divided, first, into *green marshes, swampy bogs*, or *meadows*: this variety comprises those which are covered with a layer of turf, or of high grass, which finds an abundant supply of nutriment in the upper stratum of the soil. And secondly, into *peat marshes, sterile bogs*, or *furze land*, on which nothing but mosses and a few other plants grow, as the yellow star of Bethlehem (*ornithogulum luteum*), marsh ledum (*ledum palustre*), sweet gale or myrrica, common and crop-leaved heath, (*erica vulgaris et tetralix*), &c.

Marshes of the first class, although constantly moist and wet, yield some little hay, but this is in general far from being nutritious; it is unpalatable to cattle, and very often unwholesome; besides, it can only be secured in very dry seasons: cattle cannot be pastured on such land without danger.

Peat marshes yield scarcely any pasturage, and no produce; but the peat which may be obtained from them is very valuable.

Neither of these varieties can be rendered fertile until the soil is thoroughly drained and rendered healthy; and this drainage must be effected by such means as the nature of the circumstances may seem to indicate. Considerable sums are often expended in this operation to little or no purpose, on account of the cause from which the wetness arises not having been clearly ascertained in the first place.

If the superabundant humidity of the soil is caused by the stagnation of water which falls from the neighboring hills and elevations, and settles in the valleys and on the low grounds where it can find no vent, and where an impermeable layer of earth prevents it from penetrating deeper into the soil, the first thing to be ascertained is whether or not a canal, the bottom of which shall be on a level with the marsh, can be dug on the declivity of the neighboring hill. If the expenses attendant on the formation of such a canal do not exceed the profits which may be expected to be derived from the advantages resulting from the drying of

the marsh, it should be immediately attempted; the canal should be formed after the manner which we shall presently direct.

But where such a mode of proceeding is impracticable on account of the marsh being surrounded on every side with high grounds, recourse may be had to another mode of operating, which consists in finding an outlet for the water through one of the inferior strata of the soil; but this can only be effected in places where the marsh is above the level of the surrounding country, or of the nearest river or pond. It is very seldom that marshes situated on plains can be drained by means of the substrata of the soil; but where it is possible to have recourse to this mode of proceeding, and where holes are bored in the bottoms of the drains intended to carry off the water, these latter may be filled up with rough stones and afterward covered with earth, as the water will have room enough to flow between the stones. When the marsh is once drained, other ditches may be connected with these drains, which may also be covered up after having been filled with branches.

If, as frequently happens, the dampness arises from springs, the essential point is to discover the level or hight at which these break out. Sometimes they show themselves at the edge of the marsh, in a position rather higher than that of the spongy earth. When in this position they may be carried off by a drain, or by holes bored in the soil with an auger, and the marsh thus dried without the necessity of cutting through its whole extent. By this means the important advantage of gathering the water on the highest spot is attained, and thus being able to carry it off with greater facility. In general, the only way of conveying it to some brook or reservoir is by excavating a canal of some size along the bottom of the marsh. If, on the other hand, the springs rise ever so partially from the bottom of the marsh, there is nothing can be done but to form a large drain or canal for carrying off the water across the marsh; which canal shall be on a level with the bottom of the spongy stratum, and formed in the moist soil after the manner which we are about to describe, in order that the water contained in it may be conveyed away from the land through a conduit of solid earth.

If the humidity of the morass is occasioned by some reservoir of water, either in the vicinity or at at a little distance off, the surface of which being generally or occasionally above the level of the marsh, communicates with it through the permeable strata, or else by means of the veins of the soil, a state of things which will occur even when the morass is separated from the water by a high hill, the first point to be ascertained is whether or not it is practicable to carry off the water by means of some spot, or through some drain situated lower down. Sometimes it is impossible to get rid of the water, otherwise than by means of an open canal or trench leading toward the place where it rises from below the surface: this is the case in places where rivers overflow and then return to their former bed. When these rivers are surcharged, a portion of the water contained in them being compressed by that which is above it, penetrates into the surrounding earth, which it slowly filtrates through, and runs into adjacent land, or even into land at some distance: it often happens that the period when the moisture of the land is most apparent, is exactly that at which the river subsided: the water remains in the spongy soil, rendering it moist and unfertile; until by degrees it is evaporated, or rejoins the river. The evils resulting from these circumstances may be remedied by digging a ditch, which shall, when the river has subsided, carry the water either directly or indirectly back to the river at some lower point. Every time there is an overflow, the mouth of this ditch or canal should be closed by means of a gate or sluice, unless it is the intention to irrigate some portion of the land, and it should be opened again as soon as the water has subsided. For this purpose, as I have before said, sluices are made use of, which open and close of their own accord.

A marsh cannot be intersected with ditches until the chief drain has been formed in the the solid ground. When the morass is large and deep, this can seldom be effected at once, but must be the work of several years; because the spongy substance of which the marsh is composed is so full of water as to render it impossible to make the drains of the proper depth. In the first place, the principal drain is only excavated to the depth of a few feet, or as far as the moisture will permit. The following year this ditch is deepened, and not only extended in a direct line, but also made to throw off ramifications from its sides in various di-

rections. On the third year the water will be so much dissipated, and the surface of the soil so much dried, that the principal drain may be excavated to the requisite depth, and both that and the ramifications extended. The spongy matter which had been swelled up by the water, will then decrease in size and sink down until the drain becomes scarcely half so deep. This substance also contracts as it dries, so that the drain becomes wider and requires a slope which it had not before, and which is never given to drains of this description.

Those marshes which contain a certain thickness of peat, may be brought into cultivation either without the peat being removed or after that operation has taken place. I shall not enter into any particulars respecting the removal of the peat,* but confine myself to what has relation to draining and cultivation, properly so called; but this cultivation can only be bestowed on turf pits which have been regularly worked out. When a marsh is no longer to be maintained for the sake of its peat, but is to be brought into cultivation, it is usual to leave a thickness of from nine to twelve inches of peat. Care is always taken to restore to the soil all the black earth which was attached to the peat. Wherever it is possible this black mould is mixed with fresh soil, procured from some neighboring spot or from the land itself, either from the sides of the drains or by digging in various places and excavating beneath the peat. The peaty mould thus receives a greater degree of consistence, and is rendered capable of bearing all kinds of crops. If, at the same time, an amelioration of stable manure can be bestowed on the land, or, what is equally efficacious, a plentiful amelioration of lime, the soil becomes at once excessively fertile; it must not, however, be made to bear consecutive crops of grain unless its fertility is maintained by repeated manurings. In Holland and in Friesland, it is well-known that if we would preserve the fertility of the soil we must lay it down as pasture land for a while, or an abundance of manure must be procured for it by making it bear alternate crops of grain and fodder. The immense produce yielded by land that has once been a peat marsh, causes all landed proprietors to lose no time in bringing these portions of their estates into cultivation, as soon as they have taken off the peat; and not, as formerly, to be content with the trifling profit arising from the renewal of the peat.

If the operation of draining has been properly performed, the land will be as well adapted for the growth of corn as for the meadow land; and should the latter be preferred, it can in general be well watered by means of more or less complicated arrangements. But where the drainage has been imperfectly effected, it will be better to form plantations of alders and willows upon it, as these trees grow very rapidly, and yield a great deal of fire-wood; which is much more valuable and useful than the newly formed layer of peat would be.

Where it is impossible to manure the land, the plants of which the peat was formed will at first continue to shoot up here and there, but these will gradually give way to other and better ones; especially if the under part of the soil is tolerably dry, and the land well watered and irrigated.

When marshes, from which the peat has not been taken, are drained, or such land as is covered with reeds, rushes, or plants of a similar nature, they may be broken up with a plow; or, if not firm enough to bear the pressure of the feet of the horses, tilled with a mattock.

When the dry season comes on, the ground thus turned up should be set on fire, and the combustion commenced from the side on which the wind blows; thus, both the peat and the roots of all the plants will be reduced to ashes very speedily. Some persons advise the land being burned without being plowed, but the advantages attendant on such a course of proceeding are neither so great nor so certain, because the action of the fire cannot be carried to a sufficient depth; nor is it so uniform, and therefore the roots of the plants are only partially, if at all, destroyed. Where the marsh is excessively spongy, and consists chiefly or solely of vegetable substances, it is almost impossible to calculate on its being thoroughly drained. The inequality of the effects of the burning can never be wholly remedied nor prevented, nor the asperities thus formed avoided, but the latter may easily be got rid of.

After the operation of burning has been performed, no time should be lost in

* Because we have a standard work on this subject entitled "Eisenles Handbuch oder theoretisch praktischer Unterricht zur Noeheren Kentniss des Forstwesens." Zweite Auflage. Berlin, 1812, A.

burying the ashes and mixing them with the layer of earth immediately underneath. Formerly it was customary to sow land thus prepared with buckwheat for several consecutive years; this plant was invariably found to succeed, and greatly loosened the peaty soil; but now, potatoes and turnips are in general cultivated, which answer the same purpose and generally yield an immense produce, and the ground is subsequently sown with rye or oats, which thrive very well, and the grain of which contains a peculiarly white flour: this property is occasioned by the ashes. The spring turnip likewise answers well on this kind of land. Barley, wheat, and autumnal rape do not succeed at all on such soils; at least until they have been ameliorated by a considerable addition and admixture of marly or argillaceous earth, or even of pure sand. After this has been done, almost any kind of crop may be sown with success.

But it must be borne in mind, that land thus brought into cultivation requires regular ameliorations of stable manure, without which it soon begins to show signs of exhaustion, and must be left at rest, or only used as pasture land; the produce of which will be greater or less according to the degree of impoverishment to which the soil had been reduced by previous cropping. Sometimes land of this nature is made to bear a succession of crops until it is absolutely incapable of producing any thing more; when such is the case, the only way of restoring its fertility is to leave it at rest for a considerable period, and bestow repeated plowings and ameliorations on it during that time. Some say it is a good plan to burn it again, and assert that its fertility is thus renewed.

IRRIGATION.

Almost all agricultural writers have combined the relation of all particulars relating to irrigation with instructions concerning the cultivation of meadow land. There is, however, a species of irrigation which is not intended to fertilize meadow land: from the remotest ages this operation has been had recourse to for the improvement of wheat land, and of land devoted to the growth of other crops; this is especially the case in warm climates. We shall, therefore, now speak of general irrigation, and leave the consideration of that destined simply to benefit meadow land until we come to that division of our subject.

Irrigation will be found to be connected in more ways than one with the subject which we are now upon, viz., draining; because both these operations must be preceded by the same research, and the same inquiries as to the level or hight of the water, as well as because the rules laid down for the formation of drains will be equally applicable to that of irrigating canals: and the draining and drying of land must, of necessity, precede its irrigation, and is intimately connected with it. In fact, one of the most essential points required in a soil which we wish to irrigate is, that there shall not be the slightest trace of moisture in its inferior strata, but that it shall be thoroughly dry; wherever such is not the case, irrigation, so far from proving beneficial, will inevitably be productive of the worst possible effects. But there are many cases in which it is easy to collect the moisture which settles below the surface of the soil and there become stagnated, and carry it off to such a position as will enable us to employ it with advantage in the irrigation of those very soils which it previously rendered damp, unhealthy and sterile. Lastly, irrigation can never prove really beneficial, excepting where we can turn off the water from the land and pleasure, and drain it again immediately after it has been watered.

Irrigation certainly is one of the most useful and important of all the operations that come within the province of an agriculturist. It is well known to all persons that moisture is an essential condition to vegetation, and that water, either directly or by its decomposition, contributes materially toward the nutrition of plants. The difference which exists in the fertility of various kinds of land depends chiefly upon their greater or less disposition to retain moisture. Sandy soils, which, on account of the facility with which water evaporates and escapes from them, are regarded as almost if not absolutely sterile, may be rendered as fertile as the richest argillaceous land, and equally capable of producing the greater part of our most valuable crops, and certainly of our most useful vegetables, if care is taken to preserve them in a proper state of humidity; that is, provided they contain a sufficient portion of soluble humus. Where this is the case, a sandy soil is often found to be better adapted than any other to most of our profitable crops;

it is peculiarly favorable to such as are liable to suffer from excess of moisture. When the requisite arrangements have been made for watering the soil, such a degree of moisture or of dryness may be communicated to it as best agrees with the nature of the plants which it has to bear.

Almost all water carries with it fertilizing particles which are exceedingly beneficial to vegetation. Water which has stood for some time on the surface of a soil will always contain nutritive matters which it has collected during that period, and the quantity of them will be proportionate to the richness of the land over which it has passed.

This nutritious matter, which would otherwise be precipitated into the depths of the sea and lost, is retained by means of irrigation and deposited on those soils which are watered, where it contributes to the maintenance of fertility, and to the reproduction of new plants. Water which rises from the ground usually carries with it particles of lime or gypsum (sulphate of lime) dissolved in carbonic acid, and consequently divided into impalpable molecules. When the carbonic acid disengages itself in the air, these two substances which are so favorable to vegetation become precipitated on the watered soil. It is on this account that the efficacy of irrigation is so much greater on that portion of the land which lies nearest to the spot where the water rises, and where it contains the greatest quantity of lime.

By means of irrigation we obtain and make use of a species of manure which would otherwise be lost to vegetation, and which could not be obtained in any other way; and we procure a crop which produces fresh manure without having required any in its production. Thus we, in a manner of speaking, create in our land fresh elements of vegetation.

Irrigation renders us in a great measure independent of temperature; for by means of it we are enabled to do without rain for a considerable period, as is evident from the fertility of the watered lands in the warm, dry climate of Italy, where it often happens that not a single drop of rain or even dew falls for at least four months.* We are also enabled by its means greatly to diminish the mischief done in the spring by white frosts or by frosts in general, because the water, especially when it rises from fresh springs, warms the soil by its higher temperature, covers it with verdure, and renders the meadows luxuriant at periods when land which has not been watered scarcely shows any traces of grass; and because the water, whatever may be its properties, diminishes the pernicious effects of frost of all kinds on plants when it is suffered to pass over them in the spring. By means of irrigation, we are often enabled to produce an eminent degree of fertility in land, which before yielded but a very small amount of produce. These are, I should imagine, sufficient inducements to set about the formation of arrangements for watering land wherever it is practicable so to do.

It not unfrequently happens that every facility presents itself for undertaking this operation on a most extensive scale. There are many districts, and even whole provinces, in which there is no spot, however distant from or above the level of the water it may be, which cannot with proper management be made to participate in all the advantages resulting from irrigation. If all the natural water-courses were intersected at their highest point, and the water retained in canals formed at a proper elevation, it might be made to irrigate countries where at present such a thing is scarcely dreamed of.

But even when large establishments for the purpose of watering land, which require the concurrence of several landed proprietors to perfect them, and which must be supported at public expense, cannot be formed, it very frequently happens that a considerable extent may be irrigated where such a thing has never before been attempted. Hitherto, when landed proprietors or agriculturists have determined upon irrigating their land, they have only directed their attention to the low grounds in the vicinity of some river or brook, although these are the very positions in which the operation is productive of least advantage, and they have totally overlooked the higher and rising grounds where it would have been incalculably more beneficial. It is a fact which is demonstrated both mathematically and physically, although often disregarded or misconceived, that water which

* The dews appear to me to be much more heavy and abundant at Romagna than they are in France and Italy; and it is to this circumstance I am inclined to attribute the slight effect which drouth seems to exercise over plants in the former country compared with those in the latter. [*French Trans.*

flows on an elevated or rising ground, must, of necessity, extend itself both laterally and horizontally when its course is impeded and it is prevented from descending to the lower parts of the country; consequently, it can be conducted to all those spots which are not above the level at which it was arrested, provided that we are enabled to prevent it from sinking into the earth.

In general, water which descends from some hight to a lower spot with more or less impetus, that is to say, with greater or less swiftness and force, and passes across some country, hollows for itself a bed in the lower parts of the country and there forms divers windings and sinuosities. Every brook, therefore, flows in a valley of greater or less extent, surrounded with higher ground. It frequently happens that when we consider these hights from the bed of the brook or river, they appear so elevated that many persons can scarcely conceive how the water which flows along the valley can by possibility be carried to them. But a careful leveling will prove that the point at which the water enters the valley is much higher even than these rising grounds, which at first sight appear inaccessible to the water. If, then, we cut off the water by means of a sluice or weir at the highest point, which we will suppose to be a hight of 800 perches; and if above this sluice we dig a canal which, taking the water from the bed of the brook, carries it on at an equal hight and with as little slope as possible, this water may be made to irrigate all those parts of the hill bordering on the valley which are a few degrees below the point at which the stream was cut off.

Experience and skill will, doubtless, do much toward enabling us to perceive at once the best way of turning to account the water and land at our disposal. But, however well acquainted we may be with the details of the operation, we must never rely too entirely on these, but before putting any plan, however feasible it may appear, into operation, take levels in all directions and from all points most carefully, and test each observation by repeating it again and again. We shall thus be able to ascertain how far our first estimate was correct, and shall become convinced of the possibility of carrying water to hights, where such a thing at first sight appeared impracticable. While, on the other hand, we shall often find that many places to which we had fancied the water might easily be carried, are much too high.

It is not sufficient to ascertain the hight of the places to which we intend conveying the water, but we must also find out that of all those spots through which it is to pass. All hollows and low places should be as much as possible avoided; and, to effect this, it is often necessary to take considerable circuits. Sometimes there is no other means of keeping the water up to a proper hight but by making it pass over raised courses formed of earth, wood, or materials collected for the purpose. Recourse is had to this mode of proceeding when the spot from which the water is taken is separated from that to which it is to be conducted by hollows. The chief thing to be attended to here, is carefully to examine and calculate whether the advantages anticipated from carrying the water over these hollows will be sufficiently great to repay the expense of the conduit, and if there is a sufficient quantity of argillaceous earth in the vicinity to form a solid canal.

A wooden conduit or canal will often be found least expensive; but it must be remembered that such an one is much more liable to decay and injury than any other.

In some cases, when the water has to pass over a very deep soil or to be carried above another water-course, the best plan is to form an arch of stone or brick-work, and construct an aqueduct above it. But here, also, the advantages resulting from such an operation must be brought into comparison with the expenses of it.

When the levels of the water-course have been taken, the next thing to be done is to ascertain the quantity of water that can be procured, in order that the canal may be made of a suitable depth and dimensions. To do this, the quantity of water which can be found at each season of the year must be noticed, and we must take as an average that which can be collected at the driest period; for it would be perfectly useless to make a canal of large dimensions when there is not water enough to fill it.

However small may be the amount of water which we have at our disposal, it is possible to derive great benefit from it; and to ensure this, we have only to

use it as economically as possible, to collect it as soon as it has fulfilled its purpose, and use it on some lower surface, re-collect it and diffuse it over a third portion of land, and so on; but all this requires careful and skillful arrangement, for each portion of land must be made sufficiently sloping to admit of the water descending over it, and being collected at the bottom; and yet this slope must be very gentle, in order that as little of the hight may be lost as can be avoided, and that the water may be extended over as large a surface as possible before it returns to its former bed, or to the canal which is to carry it away.

Attempts have been made to demonstrate on mathematical principles the extent of land which can be irrigated by a certain quantity of water. Hypothetically speaking, this might certainly be done, but the results of theoretical and practical experience are seldom the same, because it is impossible to calculate, with any degree of precision, either the swiftness or force with which the water will flow, or the absorbing powers of the soil. A certain accuracy of the eye, which enables its possessors to judge of this point at a glance, and which can only be acquired by experience, will lead to more accurate estimates than any measures or calculations. When there is no means of acquiring this experience on the spot or in its vicinity, on account of there being no undertakings of a similar nature formed there, the best plan is either to visit districts where they do exist in great numbers, or to obtain the advice and coöperation of persons who are in the habit of conducting such operations. It now and then happens that the quantity of water, especially when it flows from lakes or places abounding in springs, may be increased by enlarging the opening through which these lakes, or this collection of springs, pour themselves, because by so doing we diminish the counter pressure which stagnant water opposes to that which seeks to unite with it. In consequence of this enlargement of the opening through which the water is emitted, the springs and their veins open more, the water falls from the hights with greater impetus, and opens for itself a passage through the obstacles it encounters with much less difficulty.

This observation relates particularly to those lakes which have no apparent outlet: when one is made for them they fill much quicker than before, and supply the canal with a larger quantity of water than could have been anticipated before this operation was performed.

A third point, which in many cases is very necessary to ascertain, is, whether we have undisputed possession and right over the water and land which we propose operating on; whether we can act without being interfered with by any of our neighbors whose farms or estates lie above or below us. Such interference is but too frequent on land in the vicinity of mills, for those millers whose establishments are immediately above the place from which the water is derived, exclaim that the stream will be turned to flood their mill-dams, while those living below fear lest they should be deprived of that supply of water which is necessary to their trade. However futile and wholly without foundation these fears may be, it is often utterly impossible to prove that our arrangements for watering our land are not injurious or detrimental to the mills and property around, at least we shall find it very difficult to do so with sufficient perspicuity to meet the comprehensions of those tribunals before which the case is brought, for they are in general composed of men who, from prejudice and habit, adhere strictly to the letter and spirit of the law and those ordinances, which, being made when the science of Agriculture was in its infancy, sacrificed all general advantages to secure the safety and rights of mill-owners. There will, therefore, be every danger of our being invariably worsted in litigations on this point, and compelled to relinquish our projected plans of improvement and amelioration on account of the ignorance or egotism of the miller. It not unfrequently happens that other persons residing in the neighborhood think that they have some reason or right to oppose the progress of the operation: for example, those whose land is situated above, torment themselves with the idea that it will be impossible to close the sluices when the water rises, and, consequently, that their property is exposed to inundations; and, however absurd this notion may appear, it is one very likely to occur to ignorant or prejudiced people: those who reside below, on the other hand, fear lest their supply of water should be diminished, or that the water will come to them loaded with mud, dirty and impure. Whatever hope may be entertained that the enlightened spirit of the present age will lead to the formation

of enactments more favorable to the interests of Agriculture, it behooves us, in the present state of things, to act with circumspection when about to undertake an operation of this nature.

Lastly, it will be necessary to ascertain whether it will be possible to form or find a vent through which the water may be immediately conveyed away from the land which has been irrigated, otherwise we shall do more harm than good; and, instead of ameliorating the soil, shall, in all probability, render it damp and marshy. In by far the greater number of cases, however, this point may be easily accomplished.

The various ditches or canals for the purpose of irrigation may be classed under the following heads:

1. The *principal canal* or *head drain*, is that branch which furnishes the land we propose irrigating with water, and which retains this water at a proper hight The bottom of it ought to have very little slope, an inch in twenty perches is quite sufficient. Its width must be determined by the volume of water which will have to pass through it; as to its depth, that will depend upon the greater or less elevation of the soil in different places above the horizontal surface which forms the bottom of the canal, and the slope given to its sides must be regulated by the depth.

2. The *secondary canals* or *small mains*, are those which convey the water from the principal canal or main, or from some other ditch toward the spots which are to be irrigated.

3. The *trenches* are those which give out the water on to certain portions of the land to be irrigated; these are usually furnished with small banks through which are bored

4. *The openings* or *holes* by means of which the water is distributed. As it would be impossible to give that degree of evenness and regularity to the edge of the trenches which would admit of the water escaping in an uniform proportion from every part of their whole length, we are compelled to have recourse to these openings, which, as they will have to resist the pressure of the water, must be made tolerably strong, and surrounded with thick turf, or lined with wood. They are not unfrequently formed of wooden rings, or of a hollow branch of willow inserted through the bank or side of the trench. It is necessary to be enabled to increase or diminish the quantity of water which passes through these openings at pleasure, and this may be done by placing turfs so as to impede the passage of the water, or small pieces of board or wood. When the meadow is not of an uniform hight, these openings are made in the upper parts. From them the water passes into

5. The *furrows*. These are either situated a little behind the bank of the trenches, or at right angles with it. It is by means of these furrows that the water is distributed over the whole surface of the soil.

They should not be too long. Twenty-one perches ought to be their utmost length: if they are made longer they soon become choked by the rapid vegetation of the grass, and the water never reaches to the extremities; the longer they are, the wider should they be made at the mouth or commencement. because the space which has then to be watered by them, viz. that comprised between the irrigating furrow and the drain, is rendered more extensive, and requires a larger quantity of water. It is needless to observe, that the openings that convey the water into the furrows must be proportionate in diameter to the width of the furrow. The furrows are usually formed by means of a spade slightly curved, which we call a furrowing spade, and a species of large turf knife which is used to cut the turf on both sides of the furrow; or a plow is made use of which is contrived expressly for the purpose.

6. *Canals* or *drains for carrying off the water*. The size of these should be proportionate to that of the irrigation canals, and they should always correspond with each other. The water must be collected from every part of the land by drainage furrows, which will conduct it to the trench intended to carry it off. It is these means of getting rid of the water at once which distinguish irrigated land from that which is damp and marshy, and without them it is impossible to obtain that increase of fertility and of produce which may, under proper arrangements, be anticipated from this operation.

The canals intended for the purpose of carrying off the water are similar to those which convey it to the land. The *principal canal* or *drain* is that which receives and carries off all the water which flows from the whole surface of the irrigated land. Sometimes it is the bed of that same river or brook from the superior or upper part of which the head main or chief irrigating canal is supplied. The *secondary canals* are those which take up the water from a part of the irrigated land, and convey it either to the principal canal, or to some fresh portion of ground which is to be watered; where the latter is the case, this *secondary drainage canal* becomes in its turn a *secondary irrigating canal*. It very frequently happens that canals of this class fulfil both these purposes; first, receiving the water which flows from the upper parts of the land, and then conveying it to irrigate the lower portions.

It not unfrequently happens that the trenches for carrying off the water are furnished with little banks to prevent the water from escaping too rapidly, and openings are made through these banks which may be closed more or less; but this is oftener done when the land is watered by inundation, than when by irrigation.

7. The term *ditches or trenches* of *reünion*, is given to those which are intended to collect the water which flows from high grounds, and bring it to a canal raised above the level of the soil, or some large place, as for example a pond or reservoir, in which it is retained by means of a strong bank, in order to be conveyed at a yet higher level over ground which could not otherwise have received the benefit of the operation. When the trenches for carrying off the water are intended to fill this second purpose as well, they must be constructed with infinitely more care and attention.

It is impossible for any irrigating establishment to be able to do entirely without sluices of various kinds.

The construction of these sluices comes under the province of hydraulic architecture, and therefore I shall refer my readers to various works which treat of this subject.*

The *principal sluice* or *weir*, that by means of which the course of the river is impeded, and the water forced to enter the head main, is usually the largest and most expensive: indeed it not unfrequently constitutes the chief item of the expense. Many persons have on this account endeavored to do without it, and to substitute a dam in its stead; but there are very few cases in which the course of the water can be thus permanently cut off without doing mischief, and still fewer in which it is possible to pierce those dams when required, and afterward reëstablish them.

If the benefits attending irrigation can only be extended to a small portion of the land, the expenses of extending the construction of such a sluice when compared with that limited extent of surface would be very great; but where a large portion of ground can be irrigated, the expense when divided among this number of acres will be but trifling compared with the advantages accruing.

The other sluices required by the head and smaller irrigating mains or canals, as well as by the drains, may be lighter and of more simple construction, because they will seldom have to contend against the pressure of any great volume of water. The number of sluices which must be formed, will depend upon circumstances; in general, however, every portion of ground which has its own particular furrow for carrying off the water, ought to have a separate sluice. These sluices are sometimes so contrived as to cause the water to flow back to the summit of the ditch or canal; and, at others, so as to prevent it rising above a certain hight, and so that the superabundance shall fall under the sluice. In the latter case, a dam may often be substituted for the sluice.

The whole of the undertaking should be conducted on a liberal scale; for it must never be forgotten that the expense of repairing things or work that has been badly executed, or formed of common materials, far exceeds the cost of good and solid work and materials in the first place; besides, the inconveniences produced by any of the parts getting out of order are often great and serious.

In many cases, in irrigation as well as in draining, recourse is obliged to be had to subterranean conduits or pipes, made either of wood or masonry, in order to carry the water under a dam or road, or under another water-course. These subterranean canals are also frequently furnished with sluices or hatches, in order that the water may be retained or suffered to flow on as seems best.

It is often requisite to form bridges either of wood or masonry over a water-course. When these are composed of brick work, the canal must be carried on by an aqueduct; and as constructions of this nature are liable to accidents, and to be overthrown or torn up when the volume of water becomes increased, which may lead to serious inconvenience and mischief, we must avoid, as far as possible, having recourse to this plan. Dams or mounds of earth raised upon land for the purpose of bearing a canal, which is intended to transmit the water from one hight to another, often cost large sums of money; and if not constructed with the utmost care and attention, are liable to accidents. It now and then happens that, by turning and altering the course of the canal, it is possible to do without these altogether; and such a course is advisable, even though it may appear to be equally, if not more expensive.

There are three ways of irrigating land:

1. By *inundation*.
2. By *irrigation*.
3. By *causing the water to flow back in the ditches*.

In some localities matters may be so arranged as to admit of each of these modes of proceeding being alternately adopted, according as they seem best calculated to attain the end in view.

Inundation requires that the land which is to be operated on should be surrounded, either naturally or artificially, with a small mound or bank capable of retaining the water on the inundated surface.

* In the "Annalen des Ackerbaues," vol. ii. p. 529, will be found a circumstantial description of the sluices and other contrivances requisite for irrigations on a small scale. See a very interesting paper entitled "Abhandlung ueber eine Wiesen bewaesserung."

Sometimes land is inundated by impeding the natural course of the river by means of a sluice or weir placed across it immediately below the point to be inundated, by which the water is forced to flow back and extend itself over a certain surface. But this can only be effected in particular localities, and then in a very imperfect manner, because we cannot then regulate the quantity of water, the duration of the inundation, or obtain that immediate and perfect drainage which is of so much importance. It often happens, also, that it is impossible to confine the water within the prescribed bounds, and when rapid streams swell up the impediment to their course presented by the sluice, will occasion serious floods, and cause the water to wash away the soil and form embankments.

Inundations which are effected by means of an irrigation canal, which derives its water from the upper part of some river, are infinitely preferable; and especially as it is only by means of them that we can procure the advantages resulting from the watering of grounds which, though high, are below the level of the water at the spot where it passes from the river into the canal. It is likewise in this manner only that we are enabled to drain the whole extent of inundated ground at once.

Inundation possesses some few advantages over irrigation. During the winter and spring, when there is so much water, and when it is most charged with fertilizing juices and particles, we can use it thus, and retain it upon the land until it has deposited all the thick mud and slime which it bears with it. By this means the ground becomes thoroughly impregnated with water; and if a spongy soil is inundated, and then drained through its inferior stratum, it will be found to have acquired consistence and solidity.

On the other hand, this mode of watering land can only be adopted in autumn, winter and spring, and must not be attempted when vegetation and heat commence. After the first crop of hay has been gathered, it may sometimes be had recourse to, but only in a very superficial manner. When I come to speak of the cultivation of meadow land, I shall enter more fully into the subject of the necessity of ensuring the means of carrying off the water and draining the soil as quickly as possible. At present I shall content myself with repeating that the furrows and canal for this purpose must be carefully and systematically formed, must be proportionate in size to the quantity of water which is to pass through them, must have a sufficient slope from all parts of the surface which they are intended to drain, in order that the water may flow off evenly: these points are indispensable if we would attain all the good effects which may be anticipated from irrigation.

But as this mode of watering land cannot be had recourse to in the summer, when it is necessary to prevent those soils which have profited by it during the winter from becoming too dry, watering by irrigation is, upon the whole, preferable; especially for land which, from its nature and situation, is liable to suffer from drouth. The water deposits those fertilizing substances which it carries with it almost as much in irrigation as in inundation, particularly if the same water is made use of several times over, and each time on a fresh portion of land; a circumstance which cannot take place in any other kind of watering. But the chief advantage of irrigation is, that by its means we can, at all times and in all seasons, bestow exactly that degree of humidity upon the soil which is required by the plants it bears.

Land is generally irrigated in autumn, winter, and spring, for the purpose of enriching and fertilizing the soil; but the operation may be continued after vegetation has commenced, and even when the plants have risen to a considerable hight above the ground, and may be repeated as often as the temperature of the season and the nature of the soil and of the plants may appear to require it. Sometimes meadows are irrigated during the night preceding the day on which they are to be mown, in order to make the grass fresher. The ground is always watered in nights succeeding to very hot days, and this irrigation is highly beneficial to the grass, making it green and luxuriant; while that growing on land not submitted to this operation is withered and dried up. Were it not for this operation, the agriculturist would never be able to contend against all the uncertainty and extremes of temperature and climate; whereas, by its means, he nullifies the prejudicial effects of cold nights and white frosts, as well as of intense heat and drouth. As the water is kept in constant motion during the process of

irrigation, there is no fear of its producing putrefaction, or occasioning those miasmas which arise from stagnant water during dry weather.

The grass which shoots up under the influence of this kind of humidity is adapted to all kinds of cattle, and that which is eaten while green on the pasture does not injure the animals as grass does which grows on naturally damp, moist land. It is of course understood that the cattle must not be turned upon land thus watered until it has been thoroughly drained. When there is a sufficiency of water for the purpose, and every requisite care and attention is paid to the operation, even the most sterile sands may be rendered fertile, and it often happens that soils of this nature prove to be the best adapted for being converted into meadow land.

In process of time, irrigation communicates fertilizing particles even to those soils which are most sterile and wholly devoid of nutritive matter, and this effect is produced more speedily in proportion as the water contains a greater quantity of these ameliorating substances. Where it is tolerably pure, and the amelioration is in consequence left solely to Nature, it will be some time before the soil is materially improved.

The water, however, will cause the growth of lichens and mosses on the soil; which, as they putrefy, gradually produce some of that humus so necessary to the nutrition of other plants. Experience has testified that with the assistance of water, deprived of all foreign bodies, we may, in the space of ten years, create a thick turf even on the most barren sand; and, by continuing the irrigation, eventually transform it into fertile meadow land, which gradually becomes more and more luxuriant and rich. But this formation of turf and growth of grass will be materially accelerated if manure of some kind or other be bestowed on the land. Mould, or peaty substances, which may be obtained from the low country in the neighborhood, will, even if slightly acid, prove beneficial; but there cannot be a doubt that the addition of a little manure will render them still more efficacious. Where cattle and sheep are fed on land thus converted into pasture, after it has been well drained, it will attain that state of perfection to which we wish to bring it much sooner than if the grass were mown as soon as it became high enough to be cut. But with the assistance of a plentiful amelioration of manure, the most sterile and arid sands may, in one year, be transformed into luxuriant pasturage, provided that they are well watered and sown with the seed of plants adapted to that kind of soil.

Land which is to be irrigated should be as even as possible, and have a gentle slope; the furrows which receive the water from the trenches ought to pass over the highest parts, in order that the whole of the surface may be watered. The drainage furrows should be formed in the lowest part, and be made to correspond with the irrigation furrows: by means of these the soil is drained, and the water conducted into some ditch or canal intended to carry it off; and, as has before been stated, in many cases these drainage furrows serve as irrigation furrows to some other portion of land lower down.

Sometimes the trenches for the purpose of irrigation are more or less parallel with those intended to carry off the water, while at others they form a greater or less angle. The furrows and trenches for irrigation ought to be parallel when the portion of land they are intended to water is perfectly even, and has an uniform slope commencing from the irrigation furrow.

I have already stated that the irrigating furrows ought never to exceed twenty perches in length; otherwise they are liable to become choked with grass. It will be understood that every one of them must have an opening into the irrigation trench: too many of these openings should not be made on the higher parts of the land when it can be avoided.

The surface over which the water is to be extended should never be too large; but it is quite impossible to lay down any rules for determining the size of it. When the declivity is very great, the space to be watered by a single irrigating trench must be narrow; otherwise the water will hollow out channels for itself, in which it will run, instead of spreading over the whole surface. Therefore, at the distance of about every ten or twenty perches, the water should be collected by means of a fresh trench, intended to spread it over some surface lower down, and this continued until it can be used no more.

When the land has little or no natural slope, or is uneven and full of hollows and

falls, the furrows are so contrived as to form almost right angles with the trenches. The want of sufficient slope will prevent the water from running off as freely as it should do, and render it liable to settle on different parts of the soil; it is therefore necessary to have recourse to art in order to raise the middle of each division.

If the surface which we wish to free from water has natural elevations, irrigating furrows are formed on its hights, and drainage furrows in its hollows; and thus the latter are sometimes parallel with the irrigating trenches, and at others at right angles with them; or occasionally even oblique or curved: in fact, it is necessary to modify their form and direction according to the nature of the surface, if we would attain the end in view. When we wish to carry the water to the highest parts of the land, it often becomes necessary to make openings through the bank of the irrigation trench higher up than would otherwise have been expedient, and sometimes even to stop up the lower openings, in order thus to compel the water to flow back in the trench. The more even the surface which is to be irrigated, the less difficulty will there be in performing the operation; therefore, in forming a meadow, every endeavor should be made to level the soil as much as possible; and the best means of attaining this end is by additions of earth or mud brought to the land and deposited there by water, an operation which we shall presently have to describe more fully.

It frequently happens that when we impede the course of some stream or brook on the declivity of a hill, or at the foot of a mountain, we are enabled by means of a canal to conduct the water quite round this elevation, and retain it at an equal hight in all parts. Where this can be effected, all that portion of land below the canal is within the power of the water, and, therefore, may without difficulty be irrigated. In order to be able to use all the water in the brook, and, nevertheless, irrigate and drain every part of the meadow in succession, this latter is best divided into six parts.

It frequently occurs, and especially when the soil which we are about to irrigate has but little declivity, that it is impossible to do without distinct furrows for carrying off the water, which shall collect it from the upper portion of the meadow in order to convey it lower down, otherwise the whole of the land cannot be properly drained.

When the water has to pass across some low place in order to reach an elevated one, the canal must be raised throughout the whole extent, in order that the water may be retained at the level desired. If we then wish to irrigate the low grounds, openings may be made in the banks of the canal; but these latter must be neither broader nor deeper than is absolutely necessary to admit of the proper quantity of water passing through them; and as this water in falling may do mischief, or cause dilapidations, the openings we have just mentioned should be furnished with small sluices, and the water which passes through them received into channels lined with gravel.

There are districts in which a perfect system of cultivation is pursued, and this mode of irrigation applied to the most consistent and solid soils; there the water is taken from the trenches and thrown over wheat land with a shovel, and thus the plants are refreshed when they appear to require it: this mode of proceeding is usually practiced in warm, dry climates. The laborer stands in the center of the trench, and thence throws the water to the right and left as it flows toward him; all the ridges in the vicinity are thus equally and quickly watered.* It often happens that this kind of irrigation may be combined with inundation; but in order to effect this, it must be possible, by opening the irrigating canal and closing the tail-drain, to raise the water in the trenches to a sufficient hight.

In watering land, it is frequently necessary to have recourse to machines similar to those employed in draining land. Among others, drawing-wheels are employed, which are put in motion by the current of the water which is to irrigate the land. The water is then usually conveyed to the irrigating trench through pipes, and thence emitted through openings into the furrows which are to extend it over the surface of the soil. However useful the inventions of this nature which are occasionally met with may be, the construction of and keeping them

* See Simonde's "Agriculture of Tuscany," published at Geneva.

in repair is far more expensive than the establishment and maintenance of irrigations effected in the usual way; especially as the former, whatever may be their magnitude, will only suffice for a limited extent of surface. I am not certain whether the *ram* and other recent hydraulic inventions have as yet been made use of in irrigation. In England they have gone so far as to employ steam-engines for this purpose.

EARTHING AND WARPING.

In many countries, examples of this operation, which is often of such incalculable advantage, will be found. We are informed by Bernhard, that quantities of earth are thrown into the torrents which descend from the mountains, in order that it may be thus conveyed to the valleys and distributed over them, and thus raise the soil, or render it even. This operation is very common in Tuscany, where, according to Simonde, the author of the "Agriculture of Tuscany," extensive marshes are thus filled up, consolidated, and transformed into exceedingly fertile land.

But this operation has not been so extensively practiced anywhere as in the sandy districts and furze lands of the Duchies of Luneburgh and Bréme, where, during the period at which these countries were in their most flourishing condition, it became in a short time so general, that every peasant who had it in his power to put it in practice, did so without hesitation, and without being alarmed at the preliminary outlay which it required. This operation was facilitated in these districts by the formation of companies of speculative individuals, who journeyed from place to place, undertaking it for a remuneration proportionate to the extent of the soil and the difficulty of the operations. These men gradually became so skillful from practice as to require no leveling instruments save a rule and a plummet, yet they were almost always successful in their undertakings, and could estimate, with the utmost precision. the laber which each operation would occasion, and the difficulties which would present themselves during its progress.

The only person who has hitherto given a description of this operation is my friend, J. F. Meyer, in his work entitled "Ueber die anlage der Bewaesserungswiesen, besonders derjenigen welche durch schwimmen hervorgebracht werden" ("On the formation of irrigable meadows, and especially of such as are formed by additions of earth conveyed to them and deposited by water"). This paper will be found in the "Agricultural Annals of Lower Saxony," year 2, part 3; but even this is not sufficiently plain and concise to give a clear idea of all the details of the operation.

Earthing consists in transporting earth from some elevation which overhangs a valley, to the low and frequently marshy soil of the valley; and effecting this by causing the earth to be conveyed in some stream emanating from a still more elevated point; in thus forming a uniform and gently inclined surface where the hollows and elevations formerly stood, which can always be properly irrigated. The more even the surface thus formed, and the greater its slope, the more thoroughly and perfectly can it be watered; and no degree of manual labor could produce the effect of the operation of earthing.

The direction which should be given to this amelioration, and the depth to which we should penetrate into the elevation, depends, firstly, on the slope which we have; secondly, on the quantity of earth which will be required to fill up and equalize the low ground, and form, both on the surface from which the earth has been taken and that to which it is to be conveyed, an even and slightly inclined plane—such an one as will facilitate irrigation and ensure its success. If we dig too far, there will not be room enough for the loosened earth; and, instead of its being deposited, it will choke the canal, causing the water to ebb back and destroying the slope. When, however, this operation has to be extended to a brook or river, as is usually the case, we can frequently get rid of the superabundant earth by causing it to pass into this river, and so be carried off by its current. But, even where this can be done, it will be necessary to act with great circumspection, or considerable embankments will be washed up at some little distance below, and mill-streams and ponds be choked. Whenever there is the least danger of this, not a particle of earth should be suffered to enter the bed of the river; and, in order to prevent it from doing so, a dam must be thrown

up at the river side, or else a fence composed of stakes and twisted branches, which retains the earth while it suffers the water to pass through. But it will often be found to be better to fill up the original bed of the river, and substitute a canal cut in a right line. In this case a strong dam is thrown up in the river, to prevent the earth from extending beyond the spot for which it was destined.

It is also of the utmost importance to ascertain, as nearly as possible, the quantity of earth which will be required to raise the low ground sufficiently.

In order to determine this point with the utmost possible exactitude, we must measure and calculate at every spot the hight of the elevation we are about to level, and the hollows which we wish to fill up, in order to discover if they are proportioned to each other. But as the hight, depth, and width change so frequently, it is scarcely possible to have recourse to actual measurements; and, therefore, we are forced to content ourselves with judging by the eye. Besides, it is often impossible to calculate the exact quantity of earth which will be deposited, because its component parts of clay and mud will be held in solution and carried on with the water, unless we can arrest the course of this fluid for a sufficient time to allow of these matters being deposited. In an operation of this nature performed upon a marly, argillaceous soil, the quantity of mud carried away by the water was so great that the banks of the stream were covered with it for more than a mile; and yet the declivity was very gentle—the water flowed on in an equal, uniform manner—was sufficiently extended to prevent its being too deep, and several dams were formed to arrest the progress of the mud. It is, therefore, evident that earth of this kind will not fill up and equalize low ground so much as it might be expected to do. Again, if the earth brought down by the water is deposited upon a spongy, marshy soil, as is frequently the case, the ground contracts so much under the pressure of the additional earth when dry, that hollows are made even where, at first sight, the soil appeared to be quite even. Lastly, in the mass of earth which has to be brought down by the water, a great many large stones will frequently be found, which must, of course, be got rid of; and these occasion a great diminution of the quantity of earth on which we had calculated. But whenever, during the progress of the operation, we perceive that there is not enough, or that there is too much earth to fill up a certain spot, we have a remedy. In the former case we can give an oblique and slightly retrograde direction to the strip of ground on which we are operating, and which otherwise ought to run perpendicular with the canal, and thus pass the earth on to those places where it is needed; while in the latter, on the other hand, we must give a contrary direction to the water; that is to say, we must give the strip of earth an oblique direction, but one which tends toward the points which have not been filled up. If, then, the section or profile of the elevation we are about to do away with, and the hollows which we intend filling up, are not equal, we must, where there is not earth enough, hollow the bed of the canal farther into the elevation, in order to obtain a larger supply of earth; and, where there is a superabundance of earth, we must change the direction of the canal and keep it outward, so that there shall not be so much earth for the water to take up. The result of this must inevitably be that the canal will not be straight, but run in a serpentine, sinuous direction, which should in general be avoided; but in this case it is scarcely possible to manage otherwise, and we must sacrifice the advantages resulting from the canal being in a direct line, in order to attain the end and intention of the operation, viz., the formation of a slightly inclined and perfectly even surface. When the earth is of a sandy nature, and inclined to divide, a superabundance of it is by no means objectionable. The operation is certainly attended with more labor, but then the extent of low ground raised and filled up is greater; and consequently the whole expense is proportionably less than it would otherwise have been. If we have sufficient water to carry the earth, and an extent of surface large enough to receive it, an elevation of upward of twenty feet high may be leveled. It is only when the earth is tenacious and argillaceous, and must be raised by shovelfuls and thrown into the water, that the operation becomes difficult and laborious. When the elevation is of a sandy nature, the earth will detach itself, sometimes even too easily, when the water rushes against it; and in this case it will be necessary to proceed with circumspection. The strip of ground on which we intend to operate ought to be wide; and we should, as far as possible, avoid letting the principal current of the water pass too

near the elevation of earth which it is our object to remove. The earth should first be loosened from the top and thrown into the current, care being taken to keep the slope of the elevation on the side next the stream quite even and not too rapid. The same must be observed with respect to the slope which is behind the canal; we must, in throwing down the earth, take care that it slides gently and does not obstruct the channel. It often eventually becomes necessary to form an extra mound or bank to the canal on the side next the eminence, in order that the water which falls into it after heavy rains, or the melting of large falls of snow, may not injure its sides. In this case, outlets or tunnels should be carefully and solidly formed, through which this water may drain off and run into the canal.

When the elevation which we wish to remove, in order to fill up the low ground and hollows beneath, is filled with the stumps of trees, it is not necessary to pull up these previous to undertaking the operation; for their roots being laid bare by the action of the water, soon become detached from the soil. Should it be deemed requisite, they may be dug round; and, when this has been done, if the current of water is sufficiently strong, the whole stump, roots and all, will be carried down to the land beneath. The same may be observed with respect to stones of a moderate size, if the soil over which the water extends itself is sufficiently declivitous. It is only very large stones that need be rolled down or carried to some place where the ground has already been leveled. The labor of the operation is doubtless increased where these exist, but not to such an extent as it would be if we were obliged to dig into the soil in order to extract these stones, for here they are detached by the action of the water, without the intervention of any manual labor, and left upon the surface of the land; and, in by far the greater number of cases, their value amply repays the additional labor they occasion.

When we come below the level of the eminence which we wish to remove, we have nothing more to do with the earth; the water deposits it much more equally, and renders the surface of the land much more even and uniform, than any manual labor possibly could have done. Occasionally, only, when the course of the stream is impeded or turned aside by some obstacle, or takes a wrong direction, this evil should be remedied by hurdles, which should always be kept at hand for the purpose.

The bed of the river is either prevented from being obstructed, and left free and open to carry off the water, by placing hurdles at its edge, or a new canal is formed for the river in the lowest part of the ground, and this defended by a straight hedge formed of stakes and twisted branches, in front of which the earth becomes amassed, and thus forms the bank of this canal. Its bed must subsequently be deepened and cleared.

But in by far the greater number of cases, and especially where the water and earth ought to be thrown on one side only, it will be better to commence by excavating a new drainage canal a little higher up than the river, and the bottom of which shall be deeper than the bed of the latter.

Care must always be taken that the upper portion of the piece of ground on which we operate shall be on a level with the bottom of the lateral trench which transmits the water to it from the head-main; because otherwise, in the irrigation which ought to supervene, we shall have some difficulty in extending the water in one uniform sheet over the whole surface of the soil. I have said the upper portion, because at the lower part the earth is deposited by the water in such a manner as to form an even, slightly inclined surface, highly favorable to irrigation. Where this point has been attended to, it will be sufficient to give an equal depth to all the openings made in the edge or bank of the lateral trench or secondary canal. It is by means of these openings, that the water is distributed into the furrows parallel with the canal, in order to be equally diffused over the whole extent of surface.

It is only in places where the lateral trench is of a considerable length, and where all the meadow has to be watered by one canal, although not at once, but in alternate portions or panes, that various water-falls or weirs are formed; and not only the water in the trench lowered, but also the surface of the land which is to be irrigated: These walls are made of the depth of about half a foot at each division, and are regulated by small sluices formed in the irrigating canal. When

one of these sluices is closed, the water rises in that part of the canal situated above it, and ebbs back and extends itself over the land at the side. If, on the contrary, the sluice is opened, the water falls into the next portion of the canal below, or the irrigating furrow below, and does not retain sufficient hight to admit of its finding an issue through any of the lateral openings formed in the canal for the purpose of watering the land at the side. In this manner it extends itself over the second part of the land, or that which lies lower than the first, and is in the vicinity of the second part of the irrigating trench. In like manner the third, fourth, and all the other divisions are watered by turns. It will instantly be perceived how much trouble and labor is thus saved by alternately irrigating the several parts of the meadow, since all that need be done is to open or close certain sluices; whereas, under ordinary circumstances, it would have been necessary to open or stop up the openings, one after another, in the order in which we wished to water or drain each separate portion of the meadow.

As valleys formed or traversed by brooks are almost always hemmed in by two elevations, it is frequently difficult to determine whether, in endeavoring to fill up the hollow and equalize the surface, we should take the earth from both sides or from one only. Locality and contingent circumstances can alone decide this question. All we can do is to lay down a few general rules for guidance. The following are the principal considerations which must determine our decision:

(*a*). Is there a sufficient quantity of water to enable us to irrigate both sides consecutively, even during the driest seasons?

(*b*). Is the width of the valley from either side to the middle of the low ground sufficiently great to admit of the ameliorated surface repaying the expenses of the operation?

(*c*). Or is the valley of such an extent only as will allow of our being able to extend the earthing over it from one side?

(*d*). Is the soil on both sides equally proper for the performance of this operation? When the operation has to be undertaken from both sides of the valley, two separate canals must be directed over the two elevations; or, if only one canal is formed, branches must be made, each provided with a sluice, in order that the water may be made to flow from one side or the other, as seems best. One drainage canal is usually all that is required for carrying off the water, and this may be made to pass through the middle or lowest part of the valley. When the operation is to be performed from but one side of the valley, the drainage canal is excavated on the opposite side, and at as great a distance as possible, and so contrived as to ensure the edge of it being lower than the lowest part of the land to be operated on.

When an immense extent of ground is to be operated on, it is not always requisite or possible to earth every part of it. Some portions will be found which naturally present that even and inclined surface which is so indispensable to the success of irrigation. These will only require to be connected with the others by means of a dyke or tunnel, and also with the drainage canal, in order that the level may be preserved.

On the other hand, we sometimes meet with eminences which cannot be removed, either on account of the nature of the soil of which they are composed rendering it a difficult task, or because we should not know what to do with the earth taken from them. Where this is the case, the canal must be dug across the elevation, and excavated to a proper depth; or should the elevation be too high to admit of this, it may be conducted circularly round it.

The labor and expense attending this operation can neither be calculated according to any general average, nor by inference; so much depends upon locality. The formation of some meadows made in this way has not cost more than five rix-dollars per acre. This variation is chiefly occasioned by the following circumstances:—

(*a*). If the river from which we get the water be of a considerable size and width, the expense attending the making of the principal sluice will be very great. This sluice is, however, equally as necessary for ten as for a hundred acres of ground; and, therefore, it may easily be conceived that the result will be rather different when the expense has to be divided among the latter number, to what it would have been when divided among the ten acres.

(*b*). The same may be observed with regard to the principal canal or head-main, which frequently has to pass for some distance over a considerable elevation, whereby its formation is rendered very expensive.

(*c*). The quantity of water which we have at our disposal, and the rapidity or gentleness of the slope, have likewise considerable influence on the difference of expense. The more water or slope we have, the less laborious and expensive will be the operation.

In general, at the commencement of this operation of *earthing*, there is but little slope, and, consequently, more hands are required to ensure the earth being properly mixed with the water and carried down by it; but as the operation progresses, the slope is increased between the lateral canal which brings the water, and that through which it is drained off, the bed of the brook

always having some fall; thus the operation becomes less laborious, and the water acts more by its own propellent force; we can then penetrate farther into the elevation, and carry the earthing over a large extent of ground. The first portion is always the most expensive.

(*d*). The nature of the soil likewise makes a very considerable difference in the expense; where the soil is of a sandy nature, not one-third of the manual labor need be employed which is requisite on argillaceous land.

(*e*). The expense will also be less per acre in proportion as the hollows which we wish to fill up are large when compared with the elevations that are to be leveled; for the labor is confined almost entirely to these latter. The *earthing*, or in other words, the washing down and distributing of the earth, will always be best effected by the action of the water alone, or at least with very little assistance. This operation may be extended from one side over a width of forty perches: provided that there is the requisite degree of slope, the earth will be transported and deposited perfectly well to that distance. If, therefore, I wish to do away with an elevation of ten perches in hight, and fill up a hollow or valley of thirty perches of width in one place, and a hollow of only six perches in width in another, the extent on which I operate in the latter case will cost me very nearly double what it would in the former.

(*f*). The skill and activity of the workmen will likewise make some difference. When these men are accustomed to the mode of doing the work, and when the head laborer or overseer, who directs and superintends the whole operation, and especially every part connected with the lateral canal, and the upper portion of the surface on which the water acts; when this man is clever and understands what he is about, the amount of labor will be sensibly diminished without any part being rendered heavier, and many errors avoided, the repairing of which would have been productive of both trouble and expense.

This last circumstance is of so much importance that the companies of men who get their living by undertaking this operation in the Duchies of Luneburg and Brêne, execute it for much less than it could be performed by laborers hired at the lowest wages, even if the farmer superintended and assisted himself. After taking a cursory survey of the ground, these men state at once how much they shall charge for the performance of the operation, and how long they shall be about it, so skilled are they in all relating to this point. When the agreement is made at so much per acre, the sum asked is generally from eight to twenty rix-dollars; that is, supposing the soil to be light and sandy, or at any rate to contain a considerable proportion of sand.

I have undertaken the formation of a meadow of this kind here under the most unfavorable circumstances, and with the assistance of laborers who were previously wholly unacquainted with the operation; up to the present time it has cost me five hundred rix-dollars, and twenty-eight acres are actually completed. Not one of my laborers had ever seen or heard of the operation before, and I was practically unacquainted with all its details, and was, therefore, compelled to study, practice, and often guess at the proper way of setting to work.

For the first few years an establishment of this nature is always requiring some repairs: either the canals give way from their banks and sides being washed down by floods arising from heavy rains, large thaws, &c.; or else it becomes necessary to enlarge, or alter, or strengthen the openings into the irrigation trenches and furrows, or alterations are required for the purpose of being able to effect the drainage of certain low, marshy spots, or filling up these places with earth. But afterward, when every part is properly arranged and has acquired solidity, the expense of keeping in order a meadow watered in this manner is less than that of any other, on account of that uniformity of surface which renders a smaller number of furrows necessary; and also on account of the gentleness of the slope: in fact, the expense may be said on an average never to exceed six groschen per acre. I have not included in this calculation the principal sluice, which must be renewed every twenty years.

A meadow thus formed is a great while before it yields a good crop of grass, especially on the upper part, if left to the action of Nature alone, and no attempt made to assist her operations.

Where this is the case, it must not be irrigated during the few first years, or, at least, only with the utmost circumspection, otherwise the water will wash the earth from the naked soil, and form channels in it. All we can expect from such dead ground is a few plants which are indigenous, as perhaps the gray hair-grass (*aira canescens*). When vegetation does begin to appear, it is usually in the following order: mosses, lichens, and a few other similar plants are first formed; and the more completely such a meadow is covered with moss at first, the better will it be for it ultimately. When the continuous irrigations intended to earth the land have ceased, and the soil is alternately irrigated and drained, the moss perishes, resolves into mould, and thus serves to nourish the other

plants which then spring up. As the grass thickens, the moss disappears, even when no means have been taken for encouraging the growth of grasss, excepting that of bestowing frequent irrigations on the meadow; at least, as frequent as they could be without incurring the danger of washing away or channeling the ground. In general, about the fifth year after the operation, a crop of hay may be obtained which is worth the trouble of getting in; and ten years afterward we may anticipate from a sandy soil a crop yielding twenty quintals per acre. But the growth and vegetation of grass will be expedited by pasturing sheep on the land as soon as it is solid enough to bear the pressure of their feet, and begins to produce a little grass: this plan is much better than mowing, especially if care is taken that the land shall be thoroughly drained in the first place.

The fertility and productive properties of the land will, however, be called into action much sooner and more effectually if some portion of manure can be bestowed upon it. Every kind of fertilizing matter which is generally bestowed on meadow land will prove beneficial here; and folding sheep on the ground for a short time will be particularly advantageous to it. I know a case in which the folding of geese on a meadow thus formed was productive of benefit. But Nature in general furnishes us with matter, as mould, peat, and the layer of turf, which is found in the hollows. After the drainage canal has been excavated, these matters should be raised with a spade from the places where they are thickest and most plentiful, and conveyed to the upper parts of the ameliorated surface, there to be made into heaps, and, if practicable, mixed with animal dung, lime, or ashes. After the lapse of a short time, these heaps will be ready to be spread over the newly earthed soil. Where this amelioration has been bestowed, a tolerably good crop may be anticipated, even as early as the second year. There is not the least doubt but that if we sow land thus ameliorated with grass seeds, we shall expedite the period when it will produce an abundant crop. But great care must be taken in the selection of the kinds of seed and their proportions. Those plants which shoot up most vigorously during the period in which the meadow ought not to be watered, perish as soon as the irrigations are recommenced. On a soil composed of marly clay I sowed red clover, tall oat-grass (*avena elatior*), tall fescue grass (*festuca elatior*), meadow cats-tail grass (*phleum pratense*), round-headed cock's-foot grass (*dactyle glomerata*), meadow soft or woolly grass (*holcus lanatus*); and on the lower parts of the ground meadow fox-tail grass (*alopecurus pratensis*). These plants shot up and throve wonderfully during the first year, or that succeeding to their being sown; on the second year they were weaker and poorer; and at the end of four years they had totally disappeared, and given place to others. The vegetation of those parts which had been left to Nature now seemed to surpass that of the places where the above-mentioned grasses were sown. The most remarkable fact is, that of all these plants that which stood its ground best, notwithstanding the plentiful irrigations bestowed on the soil, was the red clover, which even forced its way through the moss. I should not, therefore, advise any one whose views extend beyond the few first years to sow their land with such vigorous plants, but rather to abandon the production of herbage on it to the action of Nature, unless they can select such grasses as experience teaches us are likely to produce the most plentiful and luxuriant crop on land which has thus been formed into a level surface by the operation of earthing. It may seem inconceivable, but daily experience convinces us of the fact, that those very plants spring up naturally on irrigated meadows that have not been sown at all which are best adapted to the nature of the soil, and most likely to be benefited by irrigation. Many of those grasses which would yield but a scanty crop of hay, if grown on land that was never watered, will, when springing up on irrigated meadows, yield a luxuriant crop. Where neither manure or mould is spread over the surface of the soil, there is no doubt but that it is a long time before a perfect layer of grass is formed; but if the soil is ameliorated, it shoots up much sooner, and so luxuriantly as to render it inconceivable whence this quantity of seed and germs can have come.

It is, however, essential to give consistency to the surface of the soil, in order that it may throw off the water, and I have found nothing answer this purpose so well as *spurry*. When the meadow has been *earthed* in the beginning of the summer, spurry should be sown at the latter end of the season during wet

weather, and grass seeds may be intermingled with it. As soon as this plant rises above the surface of the ground, it gives a degree of consistence to the soil which renders it capable of bearing irrigation. It never comes to maturity, because the frosts kill it, and then it rots in the ground. But when the ground is hard and solid, cattle may be pastured on the spurry, which not only increases the consistence of the soil, but also manures it, and causes it on the following year to bear a luxuriant crop of herbage, especially if a little manure is also spread over it.

Persons who have never experimented on meadows of this kind, can scarcely form an idea of the wonderful fertility which may be produced even on the poorest sand. But we have such undoubted proofs of the fact, as place it beyond all shadow of uncertainty. The more sandy or gravelly a soil is, the better is it adapted for being formed into these kinds of meadows, provided that it is subsequently practicable to irrigate them thoroughly. They may be constantly and frequently watered without any danger of their becoming marshy; and the water deposits its most fertilizing particles on the surface, while the residue sinks down into the ground. As soon as we stop the irrigation, the land dries; and when we recommence watering it, it speedily becomes impregnated. All that is requisite to ensure the vegetation of grass is moisture, warmth, and mould; the nature of the soil is a matter of secondary importance, provided that it is plentifully supplied with water. The injurious dryness of sand is counteracted where the soil can be irrigated whenever it appears necessary, and the layer formed on it by the turf, and the tissue woven by the roots of the plants serve to give it consistence.

There can be no doubt that land which has undergone the operation of earthing, especially when once a layer of rich turf and mould is formed on it, can be plowed and made to bear any of those crops which during dry weather are benefited by irrigation; whereas, if the soil was of a barren, sandy nature, no durable profit could be derived from such a course of proceeding, because the plowing would at once destroy the turf or sward, and render the land loose and friable. I have known persons who, seeing that irrigation had produced a great deal of moss on soils which had received no manure, have had recourse to plowing in order to destroy that moss, and deemed such a proceeding absolutely necessary. But here the moss is one of Nature's admirable provisions; it disappears of its own accord as soon as the grass finds sufficient nourishment for its support in the mould which has been formed on the surface of the soil, and as soon as the irrigations become more moderate. Besides, the best and quickest way of destroying it would certainly be to manure the soil, as this would promote the vegetation of the grass at the same time.

Earthing somewhat resembles an operation occasionally practiced in England, and which is termed *warping*. This, however, can only be performed where there is a regular stream or water-course which washes up mud and falls into some larger river or stream, and where, at the side of the former, or else at a greater or less distance from it, there is a piece of land below its level, which the water may be made to flood. By means of a sluice opened for the purpose, this muddy water is made to overflow the land which we intend to warp, and is retained on it until all the mud is deposited. By means of another sluice which is afterward opened, the clear water is carried off. When the ground has become tolerably dry, the muddy water is again made to overflow it, and again let off after leaving its deposit, and this mode of proceeding is continued throughout one or two whole summers. I knew a case in which a layer of muddy earth eighteen inches thick was thus deposited over a barren, sandy soil in the course of a single summer, by which means all the hollows were filled up, the asperities softened down, and the soil rendered peculiarly fertile. Not very long ago, 212 English acres of marshy land in Lincolnshire were covered with a layer of mud varying in depth from eighteen to forty-two inches, according to the elevation or hollows on the surface of the soil. This may be compared with those operations of a similar nature performed in Tuscany, of which we have already spoken.*

* In Bollonais and Romagna this operation is frequently had recourse to. I have myself performed it very successfully in the latter place, and will endeavor to give such an account of it as will give a clear idea of its details. Those rivers which flow from the western part of the mountains and hills of the Appe-

MANAGEMENT OF MEADOW LAND.

By the term "meadows" I mean to signify portions of land covered with a sward composed of various plants or kinds of grasses, and which are generally mown for the purpose of bearing hay crops. There are two classes of meadows: natural and artificial. Some persons term plowed fields which are sown with clover, lucerne, and sainfoin, for one or two years, artificial meadows; but I do not consider that they can be classed under the head of meadows at all. Neither do I rank under this head fields which are sown with different grasses, or with various kinds of plants, but which are not intended to be left in this state, and which are not covered with a thick layer or sward of these plants—a circumstance which rarely occurs in dry places where grass which is to be mown has been sown, or where the crop actually has been cut; because such herbage perishes after the lapse of a few years, and gives place to plants of an inferior kind. The kind of ground most proper for meadow land is that which is naturally too damp to admit of its being plowed. A portion of land cannot be rendered fit for an artificial meadow, until, by some operation of nature or art, that degree of moisture which is requisite to ensure the growth of the grasses has been communicated to it, and can be maintained. We have already spoken of artificial meadows when treating of irrigation.

Natural meadows are always much more humid than arable land, or are situated in damper situations. They are divided into the following five principal varieties:

1. Meadows situated on the banks of large rivers, which have either been formed by earthing, or, in a great measure, by the decomposition of aquatic plants thrown up by the water. Sometimes they occupy large valleys, and are under the influence of water-courses, which from time to time inundate and cover them with a fertilizing mud, or which saturate and perforate the substratum, and thus communicate to them the requisite degree of fertility.

2. Those which are on the banks of smaller rivers or brooks from which they derive their humidity, and by which they are occasionally watered, either through the overflowing of the stream, or by means of artificial establishments which impede the current of the water and diffuse it over the land in the form of inundation or irrigation.

These first two varieties are known by the name of *low meadows*, because they are only found in valleys or low grounds near to the beds of rivers.

3. Meadows which are situated either on eminences, or on the sloping sides or in the hollows of valleys, and which receive depositions of water which drains away from the higher ground or arable land above their level, which water often bears with it various sorts of animal matter and manure. Exceedingly fertile meadows are often found at the foot of high mountains; these receive a portion of that abundance of water which the mountains derive from the atmosphere.

4. Those meadows, the soil of which contains springs, and in which the water filtrates through the soil, shows itself upon the surface, and forms damp places, which render the land unfit for being plowed.

5. Marshy meadows, which are formed in a similar manner, and are raised by the decompo-

nines are all of them charged with more or less mud. A canal which derived its water from Santerno, and was sufficiently above the town of Imola, had been formed for the purpose of furnishing a supply of water to a row of mills. This canal crossed my farm, and furnished the land with water when required for irrigation, for the cultivation of rice, &c.

After heavy rains, the water which washed the vineyards and partially manured sides of the hills, precipitated itself into this canal, carrying with it such rich mud, that frequently twelve ounces of water taken from opposite my farm would yield an ounce of mud. The canal belonging to the mills was at this point raised ten or twelve feet above the level of the soil. Flood-gates which could be opened at will supplied those lands which had a right to it with the requisite quantity of water.

When I wished to deposit this mud over a certain extent of ground, I constructed an irrigation canal above the level of the soil for the purpose of receiving water from the principal canal and carrying it on to those portions of land which I intended to warp. Along the side of this secondary canal I marked out small squares of land each about an acre in extent, which communicated with this canal by means of small sluices or openings, and with the drainage canal by other sluices or outlets. When I wished to commence the operation, I let the water on to one of these squares, and suffered it to rise to the hight of from a foot to a foot and a half. If I wished the deposit to be light and friable, I did not suffer the water to remain there long, but drained it off quickly; while, on the other hand, if I wished to obtain a more argillaceous deposit, I retained the water there until it had parted with all its clayey particles, which, being light, would otherwise have been carried off into the drainage canal. As fast as one square was drained, I let the water on to another, and so on, until all had been submitted to the operation. When the squares are of a moderate size, the mud will be uniformly deposited and the surface rendered very even; but when they are very large, the deposit will be amassed near the openings through which the water flows on to the soil, while the more distant parts will be left almost bare. In order that the water might lose as little mud during its course as could be, the secondary canal was made perfectly straight and even, and capable of containing a sufficient volume of water to render the current tolerably rapid.

In this way I was often able, in the course of one year, to raise the layer of vegetable soil on a considerable extent of ground, from seven to eight inches or more; and the part which was thus added, being free from stones or gravel, formed a soil which, when drained and slightly manured, was favorable to almost every kind of produce, and which could be tilled with little labor. There are few agricultural operations which are productive of such real and permanent benefit. [*French Trans.*

tion and putrefaction of aquatic plants which the soil had produced. These meadows are always of a spongy nature

The soil of meadow land varies according to its position and situation. That of meadows of the first kind is either argillaceous and impregnated with a great deal of humus, or is chiefly composed of humus. When this latter species of soil does not contain too great a degree of humidity, and is not of a marshy nature, the humus contained in it is usually mild and soluble; but where the soil is humid and marshy, the meadows assimilate more to those of the fifth variety in the nature of their products, as well as in the nature of the soil.

Meadows of the second class are usually composed of soil more inclining toward sandy, and are less rich in humus, at least to a certain depth. But when this kind of land is well furnished with plants, covered with grass, and properly watered, the greater or less degree of richness in the earth below the roots of the plants is a matter of comparatively slight importance; and, where a proper degree of moisture can be maintained, a permeable sandy soil is often better than a compact argillaceous one.

Meadows of the third class are usually composed of a soil analogous to that of which the hills by which they are surrounded are composed, and their fertility is generally proportionate to that of those hills. When water charged with fertilizing particles falls from the hills to these meadows, they frequently yield a wonderful amount of produce, especially if they are well watered and their soil is sufficiently permeable to admit of the moisture draining away. That celebrated meadow in Wiltshire, which I had occasion to speak of in the third volume of my "English Agriculture," and the fertility of which would appear scarcely credible if it were not attested by eye-witnesses for this century past, is one of this class. But when this variety of meadows is found situated between portions of poor arable land, from which it only obtains scanty emanations during wet weather, or else receives such a superabundance of water as renders them marshy, causes it to produce aquatic plants, and prevents it from being tilled; while in dry weather, on the other hand, they suffer drouth, they are of little value, yield but a scanty produce, besides being in every way inconvenient from being intermixed with arable land. These considerations have frequently determined enterprising farmers on turning off or finding a drainage for the water—on earthing the land and drying it completely, and transforming it into arable land. Where the position of the meadows renders it worth while, and where their humidity is uniform, moderate, and durable, it will be highly beneficial to manure them, when their subsequent produce will thus often be doubled.

When, in meadows of the fourth variety, or those which are generally found situated at the foot of mountains and hills, the water flows over the surface of the soil without stagnating on any part, they are often exceedingly fertile and covered with thick grass, the fibres of which are fine, and the flavor sweet; this is especially the case when the water is slightly calcareous or gypseous. But if, on the other hand, the water, instead of extending over the whole surface, sinks into the substratum and there remains, rank grass springs up, containing but little nourishment, and composed chiefly of reeds, rushes, and other marshy or aquatic plants. Such land may, however, be very frequently transformed into very fertile irrigated meadow land, by being perfectly drained and freed from all its stagnant moisture.

Meadows of the fifth class are not always absolutely unprofitable. When, by the accumulation of successive layers of dead plants, they are raised sufficiently to give to the water such a degree of drainage as to prevent the land from becoming too much impregnated with it, the humus will become mild, and soluble, and fertilizing; and an abundance of rich grass will be produced, even though the substratum of the soil be so spongy and full of water that recourse is obliged to be had to extraordinary modes of carrying the hay—as, for example, wagons having very broad wheels. But when the meadows are not thus favorably situated, and are too damp, they produce anything but marshy plants, wholly devoid of nutriment, brackish, and often unwholesome—a kind of herbage which nothing but scarcity of fodder, or absolute necessity, induces the farmers to make use of.

Meadows are characterized by the denomination of acid or sour meadows.—The water which collects in the ditches is often covered with a scum of various shades, and it deposits a red-brown ochreous matter, which usually contains phos-

phate of iron. If we dig deeply, we come to portions of marsh-iron in a more or less hardened and stony state; and, in all probability, the ochreous matter brought to the surface of the soil by water arises from these. Marshy meadows on which this kind of standing water is found yield very bad fodder, especially if we do not endeavor, by digging drains, to carry off this acid and ferruginous matter from the surface of the soil. When not rendered damp by this injurious moisture, they are exceedingly fertile, and some of the very best we have.

Such meadow land may be exceedingly ameliorated by being drained, especially if we are able to turn the water again upon the soil in the form of an irrigation, if we think fit; they are likewise benefited by an addition of earth procured from elsewhere and spread over them.

In meadows of the first and second class, we must always pay particular attention to their solidity and safety from inundation; for, however favorable to them an influx of water may be during winter, or in the spring before the commencement of vegetation, it is in the highest degree injurious if it occurs when the grass is in full luxuriance, or about haymaking time; as also is it when, in the spring, the water remains so long on the surface of the soil as to destroy and putrefy the herbage. But this point depends, in a great measure, upon the nature of the rivers which the meadows adjoin. We have already pointed out the means of remedying this evil while speaking of draining.

The value of meadow land depends partly on the quantity and partly on the quality of its produce. In general, if the humus contained in the soil of which they are composed is mild, this quantity and quality will be found to be proportionate. When a meadow yields an abundance of hay, it is usually found to be composed of good plants; and in proportion as its fertility is increased, either naturally or by ameliorations of manure, will the good grass choke and destroy the bad. The only exception to this rule is in the case of marshy meadows full of acid humus, which frequently yield an immense crop of luxuriant but rank, unwholesome grass. It too often happens that, in very good meadow land, some kinds of unwholesome grasses become engendered, which deteriorate the goodness and value of the hay.

The nature of the soil of meadow land is not a point of so much importance as the nature of the soil of arable land would be. If the meadows are only properly moist, and contain a sufficient proportion of mild, soluble humus, it is in many respects a matter of indifference whether the soil is of an argillaceous or clayey nature. I mention the above conditions because, when they are wanting, an argillaceous soil will always be preferable; whereas, when there is too much humidity, a sandy soil will always be most advantageous. Where the soil possesses a sufficient and suitable degree of humidity, it is not necessary that it should be impregnated with humus to any great depth, because grass derives the chief part of its nutriment from the surface of the ground, and its roots rarely penetrate farther than to a depth of four inches. In dry meadows, on the other hand, a deep, fertile soil undoubtedly contributes most to the abundance and luxuriance of the herbage, by retaining moisture for a longer period.

The best meadow grasses—those the reproduction of which is most favored by the fertile meadow lands, and which, by the rapidity and luxuriance of their growth, afford the most ample testimony of the goodness of the soil—are the following:

Meadow fox-tail grass *(alopecurus pratensis)*, smooth-stalked meadow grass *(poa pretensis)*, rough-stalked meadow grass *(poa trivialis)*. An abundance of these three varieties is a certain sign of great fertility.

Annual meadow grass *(poa annua)*, reed meadow grass *(poa aquatica)*. This is the best of all grasses for damp places, notwithstanding its resemblance to reeds.

Tall fescue grass *(festuca elatior)*, floating fescue grass *(festuca fluitans)*, rough-headed cock's-foot grass *(dactylis glomerata)*, crested dog's-tail grass *(cynosurus cristatus)*, meadow cat's-tail grass *(phleum pratense)*, yellow oat grass *(avena flavescens)*, tall oat grass *(avena elatior)*, red clover *(trifolium pratense)*, creeping white clover *(trifolium repens)*, various kinds of trefoil, and especially the common bird's-foot trefoil *(lotus corniculatus)*, meadow vetchling *(lathyrus pratensis)*, tufted vetch *(vicia cracca)*, black medick *(medicado lupulina)*, hop trefoil *(trifolium procumbens)*, yarrow *(achilea mille-folium)*, common carraway *(carum carvi)*.

The last-named plant is, however, generally destroyed in meadow land, because pigs are so fond of it that it is impossible to prevent them from breaking into and injuring the meadows where it grows.

The following do not yield so large an amount of produce, but must, nevertheless, be classed among the good meadow grasses:

Perennial ray grass *(lolium perenne)*, common quaking grass *(briza media)*, meadow, or soft woolly grass *(holcus lanatus)*, sweet-scented spring grass *(anthoscantum odoratum)*.

The last two are not, in my opinion, so good as they are generally considered to be.

Sheep's fescue grass *(festuca ovina)*, hard fescue grass *(festuca duriuscula)*, downy oat grass *(avena pubescens)*, brown bent grass *(agrostis canina)*, knee-jointed fox-tail grass *(alopecurus geniculatus)*, meadow oat grass *(avena pratensis)*, bulbous stalked cat's-tail grass *(phleum nodosum)*, blue flowering hair-grass *(aira cærulea)*, soft brome grass *(bromis mollis)*.

These only grow on marshy meadows, of which they often form the chief produce. Various kinds of clover must also be ranked here.

Common cow parsley *(chærophylum sylvestre)*, cowslip *(primula veris)*, scabious *(scabiosa)*, burnet and small burnet saxifrage *(poterium sanguisorba officinalis et pimpinella saxifraga)*, gentian *(gentiana centaureum)*, common brunella *(brunella vulgaris)*, common marjorum *(origanum vulgare)*, wild thyme *(thymus serpillum)*, rib grass, common and large *(plantago lanceolata media et major)*.

The plants generally indigenous to bad meadow land, or such as is of a doubtful quality, are the following:

The various kinds of horse-tail *(equisetum)* which do not form good pasturage for cattle, but are well adapted to horses and sheep when the ground on which they grow is dry. The best of all these is the river-horsetail *(equisetum fluviatile)*, which is very palatable to horses, and forms excellent food for them both in a green and a dry state.

The various kinds of crow-foot. All these grasses are in their nature acid; but some of them lose this property when dried. The creeping crow-foot is the sweetest, and this grows spontaneously in meadows.

Yellow cock's-comb *(rhinantus crista-galli)*. When this plant is young and in flower, it forms a very good sweet fodder; but at the time when the hay is usually mowed it has lost all its succulency, and become so dry as to resemble straw when mixed with the hay. This plant sheds its seed very early in the year, which causes it to multiply with great rapidity. The best way of destroying it is to cause it to be eaten off the land by the cattle in the spring.

Common marsh marigold *(caltha palustris)* is also agreeable to cattle when given to them while young, and it decks the meadows with its brilliant yellow color; but when it grows older it becomes disagreeable to animals.

The various kinds of docks *(rumices)*, and especially of sorrel, frequently occupy the greater part of land in high, dry meadows. When mown while young, they yield a tolerably abundant crop of fodder. Nevertheless, they rank among some of the worst meadow grasses. The different varieties of colt's-foot *(tussilago)*, which with their large leaves choke up plants, yield but a scanty nourishment to cattle.

Spotted persicaria *(polygonum persicaria)* is eaten by cattle while young and tender, but deteriorates from the value and goodness of hay with which it is mingled.

Common tansy *(tanacetum vulgare)* is a plant which has a large root, possessed of great medicinal virtues in some diseases of horses and sheep, but which yields fodder of a very disagreeable flavor. It is seldom found excepting on the highest edges of meadow land.

Common water-drop wort *(œnanthe fistulosa)*, is propagated very rapidly in damp situations; but cattle do not willingly eat it. The same may be observed with respect to hemp agrimony *(cupatorium cannabinum)*.

Corn mint *(mentha arvensis)* has a very injurious inflence on the milk of cattle eating it.

Lady's mantle *(alchemilla)*, both the long and the round-leaved varieties cover the soil with their leaves, and their juices are suspected to be of an acid nature. The same observation may be applied to the mouse-ear *(hieracium pilosella)*, which is disagreeable to cattle, and imparts an unpleasant flavor to their milk.

Lastly, all the sedges and rushes *(carices et junci)* belong to list of bad meadow grasses. Every care should therefore be taken to free the soil from the above-mentioned plants, which may be effected by preventing them from attaning maturity and shedding their seeds, and by manuring the soil.

Similar objections may be urged against the varieties of mosses and lichens.

The following plants are actually poisonous, and, consequently, in most cases are exceedingly injurious to the pastures on which they grow, rendering the whole crop unwholesome:—

Common henbane *(hyoscyamus niger)*, thorn apple efficinal *(datura stramonium)*, water cowbane *(ciluta aquatica)*, water hemlock *(phellandrium aquaticum)*, strong-scented lettuce *(lactuca virosa)*, broad-leaved water parsnip *(sium latifolium)*, common fool's-parsley *(æthusa cynapium)*, spurge *(euphorbia)*, the various kinds of anemone or wild-flower *(anemone)*, common meadow saffron *(colchicum autumnale)*.

Every endeavor should be made to destroy and extirpate these plants; and in order to effect this they should be torn up from the meadow whenever they appear. The goodness of a great number of our meadow grasses, and their adaptation as food for various kinds of cattle, both in a green and a dry state, is a point which merits the strictest examination.

Hasselgreen has certainly furnished us with an account of the experiments made by the pupils of Linnæus with different grasses on cattle, sheep, goats, pigs, and horses, with the view of discovering how far they were agreeable to the palate and adapted for the nourishment of these animals. But this account contains so many false statements that we scarcely dare give credence to any. Among other things he states that corn spurry (*spergula arvensis*) is rejected by cattle; whereas there is no plant which they eat with such avidity and pleasure.

The plants of the first class, with many others—for I have only mentioned those which are most frequently met with and are most remarkable—form a layer or crust of turf or sward with the tissue of their roots. This crust is composed both of living and dead roots, and of the mould resulting from the decomposition of the latter. A thick layer or sward of this nature is nòt easily obtained from pasturage composed either of one or many kinds of grass artificially sown. In order to produce it, the plants must not only be such as agree with one another, but they must likewise be sown in suitable reciprocal proportions; and these proportions, as well as the selection of plants, must be in accordance with the nature of the soil and its properties. Consequently, it often happens that when we sow grass seeds, we obtain fields of grass, but not meadows properly so called. We obtain high, but not durable and closely grown grass, and never an actual sward or turf; and very frequently the plants which have thus been sown, totally disappear and give place to others. Even when fields thus sown with the choicest variety of grasses, after the crust of their natural herbage had been broken up by plowing, have, during the first few years, yielded a product far surpassing that obtained from natural meadows, the soil of which was of a similar quality. This luxuriance has not lasted long, but has diminished, until at length the land yielded less than even the poorest meadow ground.

But if, when sowing grasses to form a meadow, we are enabled to ascertain the exact and proper proportion of each variety, both as regards each other and the nature of the soil, there is no doubt but that we shall obtain this sward or layer of turf much sooner than if we left the soil to the operation of Nature only. But there is very great difficulty in determining the ratio of this proportion. The most important point is to mingle a proper quantity of long and short, of early and late grasses, the former of which yield the first crop or cutting, in conjunction with the latter, which also yield a second crop or after-grass. Some farmers, who have ascertained or guessed at this proportion, have succeeded in forming good meadow land; while others, who have been less fortunate, have obtained such poor pasturage that they soon plowed the ground up in order to sow it with other and more profitable crops.

From what I have seen, I have been led to consider that the mode of proceeding which I am about to describe is the one best calculated to obtain a good collection of grass seeds. I must not be understood to confound meadow land with those fields which are sown with herbage, and which are only intended to remain in that state far a limited period. Some spot is chosen in a meadow, the soil of which is similar to that of the one which we wish to form, especially as regards the proportion of humus contained in it, and its degree of humidity; some spot, I say, is chosen which yields particularly fine herbage; every care is taken to free it from weeds, and it is reserved for the production of seed, its fertility being maintained by ameliorations of manure. The grass is suffered to grow until the seeds of the early varieties begin to ripen; it is then mowed and dried for the purpose of being made into hay, care being taken to move it about as little as possible. Another portion is allowed to grow until the seeds of the later grasses have attained their maturity, and then it is cut down and dried in a similar manner. These two portions of dried grasses are then mixed together and threshed on the barn floor, and the dust and seed swept up, and sown on the soil of the ground which we are about to form into a meadow. This mode of proceeding appears to me to be not only the most certain but the least expensive way of obtaining a proper mixture of good grass seed fit for the formation of durable meadows, as, here nothing is wasted, because the hay from which the seed has been threshed, although undoubtedly not so good as it would have been had its vegetation been less prolonged, may still always be used. If the soil of the new meadow is adapted for the production of red clover, it will in general be advisable to mix some of the seed of this plant among that which we are about

to sow, because it does not fail until about the second or third year, at which period the other plants have not acquired their luxuriance; but we must always make it a rule to mow the clover as it begins to flower, and not allow it to complete its vegetation, or it will injure the other plants which do not grow so rapidly. When this point is attended to, it will retard the growth of the other plants but little, and they will shoot up and occupy the vacant space left as soon as it is mown.

Some close and attentive observers have pretended to perceive a kind of rotation among the various grasses with which meadow land is covered; that is to say, they assert that after a certain number of years those grasses which were previously most numerous are no longer found, but in their stead others, which, in their turn, again give place to fresh varieties. This may have arisen from various causes which escaped the notice of these persons; nevertheless, this assertion ought to be farther inquired into.

The quantity of hay grown on any particular spot being generally proportionate to its quality, when no bad or injurious weed is mixed with the herbage, we can almost always determine the value of meadow land by reference to the quantity of hay which it produces. It is equally difficult to arrange the various qualities of meadow land under heads or classes as it is to arrange arable land in a similar way, because there are so many gradations or shades of quality that it is almost impossible to define where one class ends and another begins. It is, however, quite sufficient for our purpose, and agreeable to our classification of arable land under six heads, to divide meadows into a like number of classes, taking as the ground work of this division chiefly the quantity of hay yielded by them, and in the lower classes being slightly influenced by the quality as well. The following are the divisions:

First class. Meadows which yield at two cuttings 2,400 lbs. of fodder or more per acre. To this class belong all those which can be watered at proper times and seasons, either by irrigation or inundation with good water, and the soil of which contains a considerable proportion of mild humus.

Second class. Meadows which annually yield from 1,700 to 2,300 lbs. of good fodder. To this belong meadows of the same kind as those in class the first, but the soil of which contains less humus; we may, however, frequently rank under this head elevated meadows, which receive the fertilizing moisture which drains from arable lands, and yield a product varying from 1,700 to 2,400 lbs.

Third class. Meadows which produce from 1,200 to 1,600 lbs. of fodder, composed of fine sweet-flavored grass. To this class in general belong meadows situated in valleys and on low grounds which have a proper degree of humidity, but which do not enjoy the advantages arising from fertilizing inundations or irrigation.

Fourth class. Meadows which produce an equal or even a larger quantity of fodder, but which is coarse and rank, and intermixed with weeds and unwholesome grasses. To this class belong all those which suffer from excess of humidity, and have no drainage, and, consequently, in which there is an accumulation of standing water always existing in the subsoil, which, finding no vent, spreads itself and stagnates on the surface. Meadows situated near forests, by which they are much overshadowed, appertain to this class. These frequently yield a great deal of fodder, but it is not nutritious, nor has it an agreeable flavor.

Fifth class. Meadows which yield from 800 to 1,100 lbs. of fodder. To this class belong those which have not sufficient moisture, and are naturally prone to suffer from drouth.

Sixth class. Meadows which produce less than 800 lbs. of fodder, and in which the herbage, though luxuriant, is of an acid nature, and chiefly composed of plants of the sprot, junci, or carices kind. To this class belong dry as well as marshy, acid meadows.

In making this classification, I have supposed the meadows to be always carefully attended to; that is to say, the mole-hills leveled, the ditches cleared out, and the land properly watered; but I have not supposed them to be manured, for even the worst meadow land may be so improved and benefited by manuring as speedily to yield a crop almost equal to that of meadows of the first and second class.

It has often been asked, what is the proportion between the value of meadow and arable land? Many agriculturists have exaggerated the value of the former in proportion to that of the latter, because, as they justly observe, if it were not for meadows the fertility of arable land could not be maintained. Others, on the contrary, have depreciated meadow land considerably below its actual value, on the plea that by a judicious cultivation of fodder plants, much more food for live stock can be raised on arable than on meadow land.

The value of meadows as well as that of arable land results from and is deter-

mined by the amount yielded by their produce, after the deduction of all expenses. But the value of fodder is much more difficult to determine than that of grain, because in general it is less salable.

In places where there are large markets for fodder and a great demand, we must distinguish between the price at which it would sell and the value of it when consumed at home. The former depends upon locality, and is highest in the neighborhood of large towns, or in places whence its water carriage is easy and cheap. No general average whatever can be given. The value of that consumed on the farm also varies. It is usually increased when there is a scarcity of provision for the winter feeding of the stock and the production of manure. In places where the crops yield a great deal of straw, and where the soil is favorable to the growth of clover, lucerne, and other kinds of herbage which constitute good fodder for cattle, the grass and hay of natural meadows may be more easily dispensed with; and in places where we are sure of obtaining from an acre of arable land much more fodder than would have been produced by an equal extent of meadow land, besides defraying the expenses of cultivation, the latter will not be more valuable than the former; indeed, in the opinion of many persons, it will be of less value. But where the arable land is not adapted for the cultivation of fodder plants, the value of hay, and with it that of meadow land, is increased. The more need there is of manure for the fields the more highly will meadow land in general be valued, especially where the soil is of a dry, sandy nature, because the produce of the arable land then depends entirely upon the meadows. On the other hand, we now and then, though not often, find countries in which meadow land is so plentiful, and where there is such an excess of hay of which there is no means of disposing, that meadows are estimated at a much less value than arable land.

As we have before observed, the value of fodder is always variable, and depends a great deal on locality. Nevertheless, on an average, in those places where there is neither a scarcity, a great demand, nor a superabundance of it, 100 lbs. of hay may be regarded as equal to one-third of a bushel of rye, Berlin measure, provided that it be good in quality and nutritious; but if, on the contrary, it be of a bad quality, it will only be worth a quarter of a bushel of rye; therefore, if, as is generally the case, a bushel be valued at one rix-dollar, the value of 100 lbs. of good hay will be about eight groschen, and that of 100 lbs. of bad hay about six groschen. At this price it may usually be profitably used in the rearing of cattle, provided that the breed most favorable to the locality is chosen. I need not observe that this value, when reduced to money, will rise and fall with the price of grain.

When the value of hay is once known, that of meadow land may easily be ascertained by reckoning the amount of hay which it has produced, and deducting the current expenses. In order to calculate the expenses, we must not consider merely the quantity of hay, but must compare this quantity with the extent of ground which has produced it. For a good meadow will scarcely cost more for mowing than a poorer one of the same extent, for the haymakers' wages will be much the same in each case. The cost of carrying the hay, loading, unloading, and forming the haycocks, depends more on the quantity of the produce than on the extent of the land. Besides, these expenses are considerably varied by the distance at which the meadows lay from the farm buildings. The expenses attending the getting in of hay from meadows at a considerable distance from the farm buildings are often double those of meadows situated nearer home; therefore no general average can be made on this point. We may, however, consider that the cost of mowing an acre of meadow land twice will be as follows:

	Rix-dol.	Gros.
Meadow land of the first class	1	12 per acre.
" second	1	10
" third	1	8
" fourth	1	8
And the cost of a single cutting or mowing of meadow land of the		
" fifth class	0	18
" sixth	0	16

According to the above data, if we deduct the expenses of the crop from the value of the fodder, we shall find that one acre of meadow land

			Rix.	Gros.	Rix.	Gr.
Of the first class,	100 lbs. being valued at	¼ rix-dollar, the whole will make	8	0 net prod.	6	12
" second	100 lbs.	¼	6	16	5	16
" third	100 lbs.	¼	4	16	3	8
" fourth	100 lbs.	¼	2	4	0	20
" fifth	100 lbs.	¼	2	8	1	14
" sixth	100 lbs.	¼	2	0	1	12

If we endeavor to determine the value of arable land by estimates founded on the triennial rotation with a fallow, we shall find that the value of meadow land of the same class will prove much higher in proportion. But we must remember that in this estimate all the divers expenses of cultivation are placed to arable land, while, with the meadow land, nothing but that attending the getting in of the crop is reckoned, and that the arable land yields straw and pasturage as well as other crops. From this I should be inclined to think that the relative value of a field and a meadow of the same class would be as two to three, if, as I have before said, the circumstances of the locality are such as not to affect this proportion. It is on this account that I have been induced to divide meadows into six classes rather than into any other number, although perfectly aware that, from the infinite variations of the average produce, I ought to have established a larger number of gradations.

I have already stated that although inundations are so beneficial to meadows, and when occurring at proper seasons so calculated to increase their value and raise them to a higher class, yet they render their produce uncertain ; it is, therefore, seldom that the crop of hay from meadows exposed to spontaneous inundations can be depended upon, because these may and frequently do occur at most unseasonable times. Nevertheless, this casualty has its degrees ; and there are cases where the occurrence of inundations are only to be feared when there is a superabundance, or extra supply, of water ; while there are others in which it occurs but once in two years. This consideration makes a great difference in the value of meadow land. There are many meadows which used regularly to yield a luxuriant crop, but which now, from the formation of sand banks or the raising of the bed of the river, yield but an uncertain amount of produce.

It is even more essential in meadow than in arable land that the surface of the ground should be perfectly level, especially when the meadows are to be irrigated either by natural or artificial means, for without this uniformity there will be danger of the water remaining and stagnating in the hollows, while it never reaches the higher spots. Meadows, the surface of which is not even, bear a very unequal crop : in dry seasons the lowest parts yield most, and in wet seasons the highest parts ; consequently, it is not easy to calculate by any general average the amount of produce which may be expected from them. Besides, where the surface is very uneven, the hay cannot be mown without difficulty.

I have already stated that the distance of the meadows from the farm buildings will cause a difference in the expense of getting in the crop ; besides, meadow land is always more valuable the nearer it lies to the agricultural establishment, on account of its then being more under the eye of the master, and consequently receiving greater attention. When it is thus situated, every thing that happens to it, every evil, can be at once detected, repaired and obviated ; whereas, if the meadow were farther off, the mischief might become serious before it could be discovered. It is of peculiar importance that the meadows should be near to the farm buildings in those places where urine or liquid manures are used.

A clever man who is called upon to estimate meadow lands will take into consideration the possibility of procuring irrigation for them by means of new arrangements ; or, if they are already irrigated, he will calculate the means of improving the existing arrangement, as well as of otherwise ameliorating the soil, and will carefully compare in his own mind the expenses of these improvements, with the benefits which may be expected to accrue from them.

It is a very essential point that no mole-hills should be suffered to exist on meadow land. These excrescences are chiefly found on dry meadows, and on the highest parts of the land, as it is there that the moles retire when driven from the lower places by moisture. Irrigated meadows, which can always be maintained in a proper state of humidity, are in general most exempt from mole-hills. Wherever the removal of these evils is not carefully attended to, not only will the operation of mowing be rendered difficult, and a circle be left standing round

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A clever man who is called upon to estimate meadow lands will take into consideration the possibility of procuring irrigation for them by means of new arrangements; or, if they are already irrigated, he will calculate the means of improving the existing arrangement, as well as of otherwise ameliorating the soil, and will carefully compare in his own mind the expenses of these improvements, with the benefits which may be expected to accrue from them.

It is a very essential point that no mole-hills should be suffered to exist on meadow land. These excrescences are chiefly found on dry meadows, and on the highest parts of the land, as it is there that the moles retire when driven from the lower places by moisture. Irrigated meadows, which can always be maintained in a proper state of humidity, are in general most exempt from mole-hills. Wherever the removal of these evils is not carefully attended to, not only will the operation of mowing be rendered difficult, and a circle be left standing round

them, which cannot be cut; but these mole-hills will furnish a retreat for mice, ants, and other insects or vermin, and increase in size to such an extent that eventually the meadow resembles a church-yard instead of a pasture land. These excrescences should therefore be cut down twice a year: in the spring, when the grass is just beginning to grow; and immediately after the first crop has been gathered in. Where this is carefully attended to, these hills will not injure meadows of some age closely covered with grass, but rather benefit them, because by this means fresh earth will be brought to the surface and extended over the ground, which is exceedingly beneficial to the grass.

Instruments of manual labor are in general made use of for the purpose of leveling these excrescences, as a spade, shovel, or fork; and care is taken that the soil shall be uniformly distributed: sometimes horse implements are employed, among which that harrow, a description of which will be found in my *Beschreibung der Neuesten Ackergaraethe*, heft ii. taf. 7, appears to me to be best adapted for this purpose. The harrow to which I refer is furnished with sharp irons in the front, while its hinder part is garnished with a quantity of interlaced thorn bushes. It fulfils all the purposes for which it is employed very effectually, without materially injuring the turf; breaking down every mole-hill and spreading the earth over the surface around; besides, the expense attending its use is much less than that of performing this operation with instruments of manual labor.

It is very difficult to level and get rid of old grass-grown mole-hills. If we content ourselves with removing them, a bare space is left which does not become covered with grass for some years. The best plan, therefore, is to cut through the layer of grass or sward by which they are covered with a spade in a cross direction, hollow out the internal part or mould, distribute it around, and then lay the turf down flat on the places where the hills stood. On meadows of considerable extent, a horse instrument termed a meadow-plane or leveler, or, as some call it, a Hungarian plow, is made use of for this purpose. It is a kind of sledge, having four cross-pieces, the first and third of which are armed with sharp irons in the form of a rake, and the second and fourth with teeth resembling those of a harrow. This instrument penetrates into the earth, tears and breaks almost all the turf of the meadow, and levels it beautifully; but it requires a team of at least six horses to put it in action. After it has been made use of, the meadow is harrowed in round harrowing, and then rolled. Notwithstanding the cost of this instrument, this has been proved to be the least expensive way of reëstablishing the fertility of meadows that are much infested with these small elevations. The breaking up of the layer of turf admits of clover and other plants adapted to the nature of the soil being sown. This operation may be considered as a kind of semi-cultivation, and may be effected without altogether destroying the old sward.

There is a great diversity of opinion with regard to the expediency of submitting meadow land to the action of the plow for a certain period. Some persons advocate this course of proceeding, and consider it as in every way beneficial to the meadow; while others, on the contrary, condemn it as injurious and prejudicial.

It is necessary, in the first place, to distinguish between those cases in which the meadow is broken up for the purpose of being ameliorated, and those in which this operation is performed with the view of deriving a larger profit from the soil than it would have yielded as meadow land, by sowing it with a rotation of other products.

In the latter case, a regular rotation is often established on it, which comprehends pasturage as well as the cultivation of corn and products of various kinds; for the land, after having borne these crops, is laid down to grass for a certain number of years, and sown with clover and other grass seeds. But this can only be done where the soil is equally well adapted for meadow land and for the production of corn. Wherever it is intended to reëstablish the ground as meadow land, the following rules must be carefully observed:

1. We must take care to avoid exhausting the soil by making it produce too many crops of corn, but must, on the contrary, carefully husband its natural fertility.

2. We must not fail to manure plentifully for the last crop which it is to produce previous to its again being laid down for meadow land; and this is the more necessary where the soil has been manured with lime to prepare it for the crops of grain.

3. While the soil is tilled, every care must be taken to eradicate and destroy all those weeds which multiply by means of their roots, otherwise they will attain such vigor as to extend themselves over the whole of the meadow.

Large crops which may thus be derived from meadow land, especially where the soil is mild, rich, and neither too wet nor too dry, by the cultivation of hemp, tobacco, large cabbages, &c.: these crops, I say, are extremely profitable, and will be, even if the meadow should afterward yield less herbage. This, however, will never be the case, if, after observing the three rules I have just laid down, a proper quantity of clover and other grass seeds are sown; but where these precautions have been neglected, it will too frequently occur.

But if, on the other hand, it is proposed to break up the meadow in order that it may produce new and better grass, such a proceeding can only prove beneficial when the herbage is choked with weeds which are thus to be destroyed: under no other circumstances can I recommend it. Many agriculturists break up their meadows for the purpose of destroying moss, but their object would have been much better attained had they spread manure or new earth over the soil. If only one single crop of grain—as, for example, oats—is taken after the texture of the soil is thus broken up, the soil will be impoverished unless manure is added to it; the meadow will be in a worse state than it was before, and the moss will soon reäppear. Wherever it is possible to procure a sufficiency of manure, a far better effect will result from its application than would have been produced by breaking up the sward. But a single plowing is seldom sufficient to destroy the weeds which infest meadow land; on the contrary, the loosening of the soil seems rather to favor their vegetation.

In order to destroy and completely eradicate them, we must make up our minds to bestow a thorough dead fallow on the ground, or else to have recourse to an operation which is more prompt and efficacious in its effects—namely, paring and burning the layer of turf. I must, therefore, refer my readers to what I have already said respecting the manner in which newly cleared land ought to be treated.

I have already sufficiently described the manner in which meadows should be sown on which the layer of turf has been destroyed by the plow; but my readers have totally misunderstood me if they imagine that it was my intention to advocate the reproduction of grass on them being left to the operation of Nature. I have met with cases, certainly, in which the meadows have thus succeeded better than when most carefully sown; but we cannot always anticipate such good results, as accident may lodge the worst as well as the best seeds in the ground. It has not, as yet, been positively determined which are the best kinds of seed, and those most calculated to flourish in certain soils.

For rich meadow land impregnated with humus, loose and moderately moist, nothing can be more likely to answer and produce a good crop of herbage than a mixture of meadow fox-tail grass (*alopecurus pratensis*) and rough and smooth-stalked meadow grass (*poa trivialis et pratensis*), either with or without clover. These seeds produce a luxuriant and vigorous layer of grass; their vegetation is continuous, and they soon shoot up afresh after having been mown; besides which, their flavor is very agreeable to cattle. But they require a soil possessing all the aforesaid qualities, and, if sown on land which is deficient in them, produce only scanty and patchy herbage.

I cannot take upon myself to determine what kinds of seed should be chosen for the purpose of sowing meadows of an inferior quality, especially if these meadows are intended to last for any period of time. When we come to treat of the cultivation of fodder plants, we shall have to speak of some kinds of grasses which are peculiarly adapted for raised pasture land, or fields situated on hills or mountains, and which will not bear being transformed into meadows.

Some persons think that a newly formed meadow should not be mown at first, but that its herbage should be eaten off by cattle. Others are of a contrary opinion. While others, again, believe that the best way of rendering a meadow luxuriant is to suffer the grass to shoot up, flower, ripen, and shed its seeds; and, subsequently, to crush its dried stalks by passing a roller over the ground.

All these modes of proceeding may be advantageous under certain circumstances. By cattle being pastured on the land, especially when that circumspec-

tion is exercised which we shall presently have to recommend, the roots of the plants become strengthened, and the plants themselves extend over the soil, forming a close, dense layer or sward. The excrements voided by the cattle improve the soil, if proper attention is paid to see that they are spread about; the folding of cattle on meadow land, and the treading of their feet, likewise contribute to favor the vegetation of grass on dry ground. Whenever a newly formed meadow is well covered with grass, but the plants appear to be weak, I should recommend its being used as pasture ground.

If, on the contrary, the grass appears to be thick, and to shoot up vigorously, and we can depend upon the fertility of the soil, it will be as well to mow it, especially if this can be done early in the season, before the plants have become exhausted by their seed stems growing.

We can only advise that the grass should be suffered to grow untouched in those places where that which has been sown is exceedingly fine, and distributed in tufts or patches, separated from each other by barren places; and it is therefore judged expedient to sow the land afresh; but this can only be done where no weeds have sprung up: should such exist it must be mown. Some advise that a few spots only which are peculiarly free from weeds should be suffered to run to seed, and that they should be separated by certain intervals of space, in order that the seed may extend itself over these intervening portions.

No weed propagated by its roots should be suffered to grow in such meadows, but always pulled up as soon as it is observed. As to weeds propagated by their seeds, they should on no account be suffered to reach maturity.

That kind of cultivation which is bestowed on meadow land by means of a harrow having its teeth curved forward, or, what is still better, that breaking of the texture and sward of grass land which is effected with instruments furnished with knives after the form of scarifiers, are the most beneficial modes of treating meadow land. They are peculiarly to be recommended for the purpose of destroying moss, notwithstanding that they act in a very indirect manner in this operation. Moss grows in places where no other plant would be able to find nourishment; it gives place to other plants as soon as they appear, perishes, becomes converted into mould, and in that form contributes to the nourishment of its successors. Aquatic mosses disappear as soon as a soil is drained, and dry mosses as soon as the land is watered. This production of Nature does not, therefore, appear to be so injurious to meadow land as to render it necessary that certain definite means should be taken to eradicate it, especially as it yields to every species of cultivation that tends to strengthen the layer of turf. But the operation of which we spoke before benefits the grass and invigorates it by giving the atmospheric air free access to its roots, and thus dividing and multiplying the plants and surrounding their stems with a layer of loose earth. It is, therefore, equally as beneficial on meadows where there is no appearance of moss, especially if the soil is tenacious, as it is on those which are covered with moss. This operation should be performed in the spring, when vegetation is commencing and when the soil is dry. It appears to be peculiarly beneficial when the soil is to be manured, the manure producing a much more sensible effect when the turf has been thus opened previous to its application. The beauty and uniformity of grass land are very much increased by the use of the roll, but it must be confessed that the produce is thus decreased.

In some places even more care is bestowed on the cultivation of meadows than is devoted to arable land, and it is to the former that the chief part of the manure is devoted. When we manure our meadows plentifully, they say, we are quite sure of having a sufficiency of manure for our arable land. In other countries, on the contrary, the farmers never think of manuring their meadow land, and deem it absolute folly to deprive the arable land of any portion of the manure for such a purpose; because meadows always yield some little produce even when left totally to themselves, whereas arable land under such circumstances becomes absolutely sterile. Meadows which are irrigated and ameliorated by the overflowing of rivers, the water of which is charged with fertilizing particles and matter, certainly do not require manure. Other meadows which do not enjoy this natural advantage should receive some kind of amelioration to compensate for the nutriment annually taken from them when they are mown twice a year especially; if this is not attended to, their fertility must annually decrease.

It should always be borne in mind that the produce of a fertile meadow may be converted into twice as much, or even more than twice as much, manure as the quantum which was applied to it; while arable land bearing corn crops reproduces considerably less manure than that which it required and consumed. There cannot be a doubt that the best way of increasing our stock of disposable manure is to apply it to the meadows, as by so doing we not only augment the fertility of these latter, but also obtain the means of manuring our fields and other places which we were previously obliged to leave barren for want of the means of fertilizing them. As this fact is now generally acknowledged by all clever scientific agriculturists, how comes it that in most countries the meadows are seldom manured? Because the quantity requisite for the first amelioration is generally raised with such difficulty; for although the manure bestowed on meadow land is sure to be eventually multiplied, yet this does not take place during the first or second years, or, indeed, until after the lapse of six or seven years, the effect of the manure lasting through this and even a longer period. It is a capital which, in the time we have mentioned, is tripled and often quadrupled; but many persons are unable to advance it without impoverishing their arable land.

The same manures which are bestowed on arable land may be applied to meadows; there are, however, some which are peculiar to the latter.

Sometimes, but not often, fresh stable manure is laid on meadows; wherever this is the case, it must be carried to the land and spread over it before the commencement of winter or early in the spring, in order that its soluble parts being dissolved by rain may sink into the soil. This kind of manure is, therefore, only applicable to dry meadows, where it may be carried during those two seasons. When the weather keeps dry, the undecomposed straw may be separated from the rest, gathered together with a rake, and used again as litter.

But decomposed dung, such as has been picked up in the farm-yard or on the roads, is much oftener used on meadow land, especially mixed up with earth. This manure, on account of the seeds of weeds which it contains, would be preju- to arable land. The sweepings of houses, saw-dust, hair, woolen rags, and the refuse of the farm-yard and out-houses, may all be added to it likewise the sweepings of granaries, barns, and haylofts are set aside as manure for meadows, because they engender too many weeds to admit of their being employed for this purpose on arable land.

Besides these matters, urine, or liquid manures which flow from the stable, or in rainy weather drain away from the dung-heaps, are set aside for meadow land. The liquid manure procured from pig-sties, and which is collected in reservoirs formed for the purpose, is likewise used. This is an exceedingly efficacious kind of manure, and should be applied to those meadows which lay nearest to the farm buildings. Sometimes a neighboring brook, or a canal formed on purpose, furnishes the means of the last-mentioned species of manure, which is suffered to mix with the water, and thus diffused over the land. Another species of manure which is peculiarly adapted for meadow land, is that obtained by folding or penning sheep upon it. This, however, can only be done on dry meadows, or such as have been thoroughly drained during the spring and autumn. Four hundred sheep penned on an acre of land for two nights will manure it completely.

Mechanical manures, or those by the means of which the nutritive substances contained in the soil are dissolved, as lime, gypsum, marl, turf, ashes, soap-lees, &c. are exceedingly beneficial, especially on very moist or very dry land. They are not, however, productive of so much benefit on poor, humid soils as on others. They eradicate moss, and expedite its decomposition; and it is this which renders them so efficacious on meadow land which is covered with moss, when applied after the soil has been drained.

Sometimes these alone are made use of; but the best way is to cause ameliorations of this nature to alternate with others of manure, or else to mingle the two together, and thus form a kind of compost. Gypsum, and the residue of salt works, form very beneficial manures for meadow land, and especially for such as is sown with clover, vetches, or trefoil, as both these substances tend to increase the rapidity and luxuriance of the growth of these plants. We must proceed with very great circumspection when ameliorating meadows with pure lime.

This substance should be powdered very fine, and spread lightly over the soil, unless the meadow is covered with moss or weeds, in which case it may be used more abundantly and in its caustic state, in order that it may destroy these injurious occupiers of the soil.

An astonishing effect is often produced from earth being carried to the meadow and spread over it. This effect is peculiarly sensible when the amelioration of earth is of such a nature as to be appropriate to the soil.

Marshy and spongy meadows covered with moss, will be improved by addition of pure sand. It has been remarked that sand washed up by water upon meadows of this kind, has often been productive of considerable benefit when spread equally over the surface of the ground; and thus what was merely the result of accident, has proved an example worthy of imitation. The more spongy and wet the meadow is, the greater quantity of sand will it bear; and even where this sand appears to have choked and smothered the turf and grass, the herbage will, in general, be found to shoot up afresh in the following year, and vegetate more luxuriantly than ever. This amelioration of sand has a tendency to depress rather than raise the soil of meadow land, because it compresses the spongy earth, sinks into it by its own gravity, and fills up all the interstices. Sand destroys moss and facilitates its decomposition.

But when meadow land is solid and consistent, some kind of fertile vegetable earth will be found more beneficial than sand. Indeed, when it can be procured, such earth will always improve meadows, because it gives to the herbage a disposition to put forth new roots and shoots, especially in the weaker tufts of grass, and thus strengthens and multiplies the plants.

H. F. Pohl, in the "Annals of Agriculture," vol. vi. p. 274 ("Annalen des Ackerbaues"), has termed this mode of spreading fresh earth over the surface of meadows, "a renewing or making young again of meadow land." He has treated on this subject at considerable length in a work entitled "Das Verjungen der Wiesen," Leipsig, 1810; which work contains a number of judicious observations on the cultivation of meadow land in general. Dry meadow land is peculiarly benefited by an amelioration of earth taken from low grounds, even when this earth is naturally inclined to be acid. Thus the marshy earth which is taken from the substrata of a soil in which ditches and drains are dug, may be beneficially employed in ameliorating the higher and dry ground, or even the upper parts of the very same meadow from which it was taken. The best plan is, however, to mix it with other earth, and then spread it over the meadow. Next to this kind of amelioration, the different kinds of marl will be found to produce the most striking benefits.

The period at which it will be most advantageous to carry manure to meadow land must not be determined without due consideration and careful attention to all local and other circumstances. Only those meadows which are neither naturally or artificially inundated should be manured before the commencement of winter, or the water will wash away a considerable portion of the fertilizing particles and juices contained in the manure. If, however, there are any portions of the meadow which, from lying higher than the rest, are not reached by the water, a considerable quantity of manure should be bestowed upon them before the winter comes on, either to compensate for what they lose by not coming within the action of the water, or in order that the manure may be spread over the rest of the ground as soon as the water has drained away.

An amelioration of strawy manure, when applied to dry meadows before the commencement of winter, is often productive of very beneficial effects, because the particles of dung then sink more completely into the earth; and this covering protects the plants from the pernicious effects of sharp frosts. But many persons believe that this practice is not unattended by its disadvantages; the long strawy manure affording a retreat to mice and insects, and attracting them; and such a warm covering rendering the grass plants too delicate in the spring, forcing their vegetation too forward, and thus exposing them to the danger of being cut off and destroyed by the late spring frosts, which often occur after the manure has been removed. On these grounds, many farmers prefer to postpone the manuring of their meadow land with strawy dung until the beginning of spring, and then leave it on the ground until the grass shoots up.

But there is no doubt that decomposed dung and compost should be applied to

meadows situated on rising grounds at the latter end of autumn, although it acts very beneficially when not spread over the soil until spring.

It is very difficult to manure wet, moist meadows, especially if they are liable to inundation, at the time which we consider most advantageous; and still more so in the spring, because at that season the land is too damp and soft to admit of the manure being carried. The best plan, therefore, is to select the period immediately following the getting in of the first crop of hay. The manure will then have time to become combined with the soil before the commencement of the heavy rains and inundations of winter, which would otherwise wash it away.—In fact, general experience seems to testify that manure is always most advantageous when carried to the ground and spread over it at this season.

Although we have already spoken at some length of the establishments and arrangements appertaining to irrigation, we have still some farther observations to make as regards the application of this operation to meadows in particular.—We have already pointed out the difference between watering by inundation, irrigation, or by causing the water to ebb back over the surface of the soil. There are some few meadows which may be watered by all or any of these three operations, yet such are rarely met with; and, besides, each of these modes of watering has its own peculiar rules.

Land should be watered by inundation in the autumn and at the beginning of spring. When the cattle have been taken from the meadows in the autumn, all the trenches, furrows, canals and sluices should be carefully examined, and, if necessary, repaired. Those which require the most special care and attention are the drainage furrows and canals, because the success of the operation depends upon the facility and promptitude with which the land can be laid dry after having been inundated; and, besides, autumn is the best season for clearing and repairing ditches, &c. The water must be let on to the soil plentifully, and suffered to rise as high as it will, and allowed to remain there sufficiently long to thoroughly impregnate the ground. When there is a great deal of water, it frequently levels an uneven soil; the waves or ebbs of its current, especially when the wind is high, washing down all the elevations they meet with. When the water has been suffered to inundate the soil early in the season, and very warm weather supervenes, we must carefully notice whether or not there is any sign of putrefaction—the existence of which will be indicated by a kind of foam or scum which shows itself on the surface of the water. As soon as this can be detected, the water must be drained off as quickly as possible, and the meadow thoroughly dried. The inundation must not be repeated until the meadow is completely dry, which will not be in less than two or three weeks.

Opinions are divided as to whether, in case of frost coming on, the water should be suffered to remain on the land, and there form ice; or, whether it should be immediately drained off. The first course has both its advantages and disadvantages. A slight layer of ice formed near the soil will do no harm. But when the surface of the water is frozen, and, from the remainder being thus held stagnant, the land is rendered wet and muddy, a degree of putrefaction will, in most cases, be produced even during the winter, which will injure, if not destroy, all the best meadow grasses. Therefore, in meadows where the water rises much, it is always better to let it off before the commencement of winter.

In the spring, as soon as the cessation of cold weather admits of the sluices rising and falling, meadow land should be plentifully inundated, in order that the water may deposit upon it all those fertilizing particles which it has acquired during its stagnation. The inundation should be suffered to continue during a period of from eight to twelve or fourteen days, according to the temperature of the weather; we must, however, at this period, even more than in autumn, attentively watch for the slightest sign of putrefaction, and, if we can detect it, let off the water directly. When the meadow has become completely drained, another inundation of about three days' duration may be bestowed upon it; and, subsequently, a third, lasting but one day. As soon as the grass begins to spring up, these inundations must be discontinued. After the first crop of hay has been got in, however, especially when the weather is dry, another inundation may be bestowed upon the meadow, which must not, however, be prolonged beyond a period of two days. But the period at which these operations should be performed, as well as their duration, must invariably be determined by attention to

the nature of the soil which is to be operated on, and the state of the weather and temperature. The more permeable a soil is, the more frequently may it be inundated, and the longer may the water be allowed to remain on the ground.—But, where the land is of an argillaceous and impermeable nature, it must not be watered so often, nor must the inundations be prolonged so much as otherwise. When the weather is dry, the land may be watered much more frequently than it should be in damp weather, and the water may be allowed to remain on the ground much longer in cold than in warm weather.

On those meadows which are watered by spontaneous inundation, care must be taken to keep the irrigating canals, furrows, and trenches, as well as those intended to carry off the water, in perfect repair and good order, so that the water may not remain on the ground one moment longer than is beneficial.

Neither in inundation or irrigation should the water be allowed to flow over the land during the hottest part of the day, as it would then be likely to do a great deal of harm. Toward evening, or early in the morning, are the periods when its action will prove most beneficial.

After a white frost, or one of those cold nights which, in the spring, almost invariably succeed very warm days, watering the soil will be particularly advantageous, as it repairs the mischief done to the herbage by the cold.

In conducting irrigation, the following points must be attended to:

If the meadow has been pastured during the autumn, and the cattle have subsequently been taken up and turned into the stalls or into the straw yard, the first thing to be done is immediately to set to work and repair those trenches and furrows which have been injured by the feet of the cattle, in order that the water may flow equally over all parts of the meadow. By means of turfs placed in the furrows, and also by raising the banks of these latter with strips of turf, the water may be retained in some places, and forced to extend itself in others. When all the repairs are made, water should be let on to the meadow, in order to see if it takes its proper course, for the pressure of the feet of cattle always deranges the irrigating arrangements more or less.

An abundant and continuous irrigation may then be bestowed on the land, in order that the soil may become saturated with water, rendered more compact, and made to settle down. After a lapse of from eight to fifteen days, the meadow must be allowed to drain, in order that it may not be rendered too soft, and afterward watered afresh. Although it is scarcely possible to irrigate land too much in the autumn, it is always best to suffer portions of it to drain and be watered alternately, even when there is a sufficiency of water to admit of the whole meadow being continuously irrigated—a circumstance, however, of very rare occurrence, especially when the meadow is of considerable extent. Wherever there is not this plenty of water, it must, of necessity, be withdrawn from one part before it can be applied to another.

Should a sharp frost come on during the period of irrigation, and the meadow become covered with ice, no harm will arise; besides, water which can flow on without interruption seldom freezes.

Immediately after the melting of the ice or snow, the sluices should be opened in order that the water may drain off quickly, as otherwise it will be very likely to do mischief. The first spring irrigation may last fifteen days or more; the meadow should then be left dry for at least eight days, after which time the irrigation may be recommenced, but the water must not again be allowed to remain so long on the land.

When the herbage begins to appear, which, where there are warm springs of water, and where the temperature is mild, usually occurs early in the season, the meadow land should again be laid thoroughly dry, and all the trenches looked to and repaired. Ewes should then be pastured on the meadow, as the herbage yielded by it at this season is peculiarly beneficial to them, increasing their milk far more than any other kind of nutriment would. In many counties of England the success of sheep breeding is believed to rest essentially on the pasturage yielded by irrigated meadow land, and numerous experiments have proved that such pasturage is exceedingly beneficial to sheep; it is only those grass lands on which there is stagnant or standing water which are injurious and unwholesome. The irrigations may then be continued, but the water should not be suffered to remain on the ground more than three or four days at a time. As the weather

becomes warmer, however, their frequency must be diminished; and, at length, they must only be performed in the night. This will depend, in a great measure, on the nature of the soil; wherever the land is sandy and permeable, and the temperature inclined to be dry, the irrigation may be repeated every fourth night, and this continued until the grass is ready to be mown. The herbage growing on an irrigated meadow should always be kept fresh and green by means of water; if it is once suffered to flag and droop, the plants, from being accustomed to moisture, will suffer much more than others would—their vegetation will cease, and there will be great difficulty in bringing them round again.

Great care, skill and attention are required in the management of irrigation; it must never be repeated until the soil has become perfectly drained, neither must it be deferred until the plants have begun to suffer from drouth. In large farms it will always be best to have a man expressly for the purpose of looking after it, keeping in order, making the necessary repairs in the trenches, furrows, &c. and regulating the periods and continuance of each irrigation.

Immediately after the first crop of hay has been got in, the irrigation should be recommenced; the first may be made to last eight days, but after that it must only be repeated in the night, and when the meadow appears to require it.

Many persons particularly recommend that meadow land should be carefully weeded, and freed from all useless and injurious plants. But where proper attention is paid to the cultivation of the soil, weeds are of no great consequence, and will never attain any great hight; indeed, where meadows are mown twice a year, all the weeds that do exist in them will disappear after the second mowing. It is not so, however, with meadows which are only mown once, as there the weeds have time to attain their full growth, especially where they happen to be of such kinds as cattle will not touch either in the spring or autumn. Some weeds may be completely destroyed by pasturing cattle on the meadow during the spring, as, for example, the cock's-comb (*rinanthus cristagalli*), the seed of which would otherwise form and ripen before the period for mowing the first crop of hay arrived. Thistles disappear when the land on which they grow is mown twice in the year; and, when cut down before they have begun to flower, they form very good fodder.

Aquatic plants are destroyed by draining the soil; which is, in fact, the only way of getting rid of them entirely. The tussilago, or colt's-foot, alone, which flowers very early in the year, and covers the soil with its large leaves, requires to be pulled up by the roots when found growing on a clayey soil. After it has been pulled up several successive times, it will be extirpated, even though some portion of its roots should be left in the soil.

When a meadow is mowed, particular attention must be paid to see that the grass along the edges of the ditches and under the hedges is carefully cut; wherever this point is not attended to, the places thus left become absolute nurseries for weeds and poisonous plants and vermin.

Care must also be taken that no shoots or suckers from the roots of trees shall be allowed to shoot up near the hedge; as they sometimes will do, extending their roots in all directions. If the meadow is mown twice in the year, these suckers, which otherwise shoot up and multiply so rapidly, will be weakened and destroyed; but where it is let alone a whole year, the scythe is powerless to destroy them, and the only way of extirpating them will be to cut them down close to the ground, or even lower if possible. It is not necessary to tear them up roots and all, which would be a task of difficulty; if the young shoots are carefully cut off, the roots will perish of themselves.

Pasturing cattle on meadow land has been very generally condemned as disadvantageous and injurious; and many farmers have consequently relinquished the profits arising from this important branch of the rural economy.

This prejudice has, doubtless, arisen from the abuses which have crept into the system, and the injury which has often been done to the land where others besides the owner of it have had the right of pasturing their cattle there; these persons have been guided by no laws, have paid no attention to times or seasons, neither have they taken any care to select the kind or breed of animals which could be pastured on the land with the most advantage. But where the farmer has used the meadow himself, and only turned his cattle into it in the spring and fall of the year, the practice, so far from being injurious, is exceedingly benefi-

cial, especially if the quality of the hay is also taken into consideration; because cattle pastured on meadows during the spring consume the early plants, which, if they were let alone and suffered to grow until the proper period for mowing arrived, would have become dry and strawy, and have shed their seed. Such grasses, however, while young and tender, are peculiarly agreeable and beneficial to cattle; although when suffered to grow and flower they become dry, hard, and insipid, and impede the growth of other and better herbage.

The spring pasturage ought almost invariably to be devoted to sheep grazing, provided that the meadows are thoroughly dry; for marshy meadows, the grass of which is defiled with mud, are always injurious to animals of this kind, although perhaps less so in the spring than they are in the autumn. But wherever the meadows have been thoroughly drained, this early pasturage is very valuable, and is peculiarly adapted for the nourishment of ewes, rendering their milk very plentiful and nourishing. These animals eat down the grass in an equal and uniform manner, and thus cause it to put forth more roots; and they restore to the land, through the medium of their excrements, as much if not more nutriment than they take from it. It is also said that they destroy or keep away various kinds of insects. Their tread and the pressure of their feet are advantageous rather than injurious to the soil; but it must be borne in mind that this pasturing of sheep on meadow land must be regulated by the state of the vegetation. When the spring is warm and early, the animals should not be suffered to remain on the land (*in the western parts of Germany*) after the 20th of April, and never after the beginning of May; but when the spring is cold and the vegetation late, they may be pastured on until the 10th of May.

It is by no means advisable that any kind of cattle should be pastured on meadow land in the spring of the year, unless the soil is so dry and firm that the pressure of their feet cannot make holes in the land, and unless care is taken to divide their excrements, and spread them equally over the soil as soon as they are voided; attention to this point can alone prevent this practice from being injurious to the meadows.

On the other hand, the autumnal pasturage, or that which follows the getting in of the second crop of hay, should be devoted to horned cattle, because the autumnal herbage is very apt to produce cachexy, or general bad habit of body, and gradual wasting away and loss of flesh; besides, there is plentiful pasturage elsewhere for these animals in the autumn. The grass which in some meadows shoots up abundantly and luxuriantly at this season is very nutritious and beneficial to horned cattle, and particularly adapted for the foddering of such as are in milk. At this period, there is nothing to be feared from the foot-marks which the animals make in the soil, because, even where the soil is peculiarly spongy and soft, these traces will always be effaced in the spring. The dung voided by the animals is likewise very beneficial, especially when it is carefully divided and spread over the ground, which can easily be done, and should be made the duty of the herdsman.

In England, where the practice of pasturing cattle on meadow land is carried to a very great extent, the meadows are seldom mown more than once in the year; sheep are suffered to graze upon them until late in the spring, and immediately after the hay is gathered in, cattle are turned on to the ground to eat off the after-grass. The same system will be found to prevail in most low countries, where the breeding of cattle constitutes the principal object of the agricultural economy. Wherever it exists to any considerable extent, a certain quantity of grass land is allowed to each head of cattle for pasturage, and the production of hay for winter fodder. For this purpose the meadow is divided into two parts, one of which is pastured, while the other is kept in reserve from the beginning of spring until the proper time for mowing it arrives; and after the hay has been gathered in, the cattle are removed from the other portion where they had previously been pastured, and turned on to this newly mown part to graze the aftermath, while the second part is allowed to vegetate in its turn until it furnishes a crop for fodder.

All the comparative experiments that have hitherto been made tend to prove, that under this system meadow land improves much more, and is rendered more fertile than it would be if mown twice in the year. The herbage is finer and thicker, and no coarse, hard stems or weeds are seen; the excrements voided by

the animals manure the soil quite sufficiently; and this mode of proceeding is greatly to be recommended under certain circumstances and in certain localities, although there may be, and doubtless are, places in which it will be most advantageous to take two crops of fodder from the soil.

Both reason and experience convince us that meadow land is much more impoverished by being mown than it is where cattle are pastured on it. Where two crops of hay are exacted from the soil, the second must always be succeeded by a manuring; whereas, the pasturing of cattle on the meadow maintains it in a state of fertility, without any extraneous means being had recourse to.

It has been found to be so advantageous to use meadows as pasture land instead of mowing them, that in some countries, and especially in England, cattle are pastured on them during the whole year. I cannot, however, recommend this proceeding being carried to such an extent; for among the various grasses which are grown for the purpose of being made into hay, those which shoot up highest appear to me to be injured by being constantly eaten down by cattle, and if long submitted to such a system, eventually perish and disappear. A meadow which has been pastured, certainly produces very fine, thick herbage, when afterward left to vegetate unimpeded; but the grass on it is always very short. If the soil is sufficiently rich and fertile to ensure a plentiful and luxuriant crop of this short grass, it may be advantageous to submit the meadow alternately to pasturage and to the scythe; but, otherwise, it appears to me to be exceedingly prejudicial to meadow land to pasture cattle on it during a whole year or more without interruption.

Meadows are divided into those which yield *one*, *two*, or *three* cuttings, or crops of hay; and the first is subdivided into early and late meadows. But this distinction depends chiefly upon the manner in which they are cultivated, and not unfrequently on the more or less exclusive right which the agriculturist possesses over these portions of land. For even those meadows which are mown but once a year are capable of yielding two crops, if properly managed, and if they are the absolute property of the farmer. The claims of others, besides the person who rents it, on meadow land, usually arise from its having, at some previous time, been common land; but these claims are so prejudicial to the interests of Agriculture, that wherever attempts have been made to increase and advance the national welfare, every exertion has been used to do away with these hereditary claims, and release the farmer from a tax which cramps his energies and impedes improvement.

THE HAY HARVEST.

The getting in of the hay crop is one of the most important of all the agricultural operations, and requires great activity and industry, as well as skillful management and constant attention.

The exact period at which this operation should be undertaken cannot be specified, although many persons pretend to lay down rules with regard to it. It is influenced not only by the nature of the soil, the situation of the meadow, and the kinds of grass which grow there, but also by the state of the temperature, and the advancement or backwardness of the season. The best way is to commence mowing as soon as the chief part of the herbage is just preparing to flower; for were we to commence sooner, the quantity of hay obtained would not be so great; and if the operation is postponed until later, the quality of the hay will be deteriorated. Where it is intended that the meadow should be mown two or three times in the course of the year, the first crop should always be got in as early in the spring or summer as is practicable, in order to allow more time for the vegetation of the other two crops; thus the second being ready for cutting sooner, the third is rendered more abundant: in those places where considerable value is set on the aftermath, the first crop of hay is always mown very early in the year.

As the difference in the temperature has so great an influence on vegetation, it will readily be understood that the herbage is not always ready to be mown at the same period. In a warm, rainy spring, the hay harvest will be at least three weeks earlier than it will be in a cold, dry season. Sometimes the vegetation of the long grasses is very forward, while that of the short grasses is altogether as backward; so much so, indeed, that it is almost impossible to commence

mowing. But it not unfrequently happens that when the short grasses are backward at the time the first crop is mown, they shoot up vigorously and luxuriantly against the period of the second mowing; this is not, however, always the case, for where the weather is dry and unfavorable, these grasses are often even more behind in their vegetation at the second than they were at the first mowing. Whenever the tops of the short grasses have suffered from frost, it will always be found beneficial to mow them, as they are thus induced to put forth new shoots. Where their vegetation has been retarded by drouth, and this state of weather is succeeded by much rain, they will shoot up very rapidly without any thing being done to them.

Temperature has in general a very great influence on the luxuriance as well as the period of the hay harvest. However vague may be the data which we possess respecting the indications of alterations of weather and temperature, and although these data are in general founded on prejudices and old saws, yet it is well known that in general there is a considerable change of temperature about the 21st of June, or the period of the summer solstice. If the former part of the summer has been dry, a fortnight's rain, or even more, may be expected. On the other hand, if the early part of the summer has been wet, and the weather seems inclined to clear, fine and favorable weather may be expected. It is on this account that those who have had their spring meadows mown early are best off in the former case, even though at the period of the mowing the short grasses were very backward, for this herbage shoots up most luxuriantly during the wet weather which succeeds to the dry. But, wherever the mowing cannot be performed before the commencement of the rainy season, it should be deferred until there is a reasonable prospect of settled fine weather again. All these contingencies should be carefully weighed, and the nature and position of the meadow taken into consideration, before the period best adapted for cutting down hay is fixed upon.

The operation of mowing requires great attention and care; it is of the utmost importance that the herbage should be cut down *as close to the surface of the ground and as level as possible*, without, however, touching the necks of the plants or injuring the sward. This, however, can only be done on even meadows which are thoroughly free from stones and inequalites. Neither can it be effected when long scythes are used, or where the mower takes long sweeps or swaths; for, although such a mode of proceeding tends to accelerate the progress of the work very much, a more circumscribed swath is to be preferred, as it enables the laborer to cut the grass closer to the ground and more equally. It makes a very great difference in the quantity of the hay crop, whether the grass is cut close to the ground or not, firstly, because the herbage is much thicker the nearer it comes to the ground; and secondly, because experience has testified that it is much more advantageous to the young shoots that the grass should be cut down close, than it should be left long and uneven.

As it is much easier to get the laborers to mow in this way when they work by the day than it is when they are at task work, I cannot but consider the former to be most preferable. Day work has also another advantage, viz. that the laborers may then be employed either in mowing or haymaking, according as they can be of most use.

Where the land is even, a man can easily mow an acre and a half per day. Skillful workmen, who mow by piece or task work, generally get through more than this, and will sometimes do twice as much; but then it is not so neatly and well executed.

There are various ways of making the hay, which are followed according to the kind of hay which we wish to have produced, and the state of the weather at the period of haymaking.

There are two kinds of hay, *green* and *brown* hay.

The quality of green hay is always improved by the grass being spread about and divided immediately after having been mown, and thus exposed to the influence of the sun and air; but it must be carefully protected from moisture, and from dew and rain, by putting it in heaps. As soon as the dew is evaporated, all the grass which has been mown in the early part of the morning should, if the weather is fine, be scattered about, and great care taken to shake it free from lumps and divide it thoroughly. As soon as this has been done, the haymakers

should go back to the spot where they commenced, and turn over or move with a rake that portion which was spread out first; at noon this should be repeated; at four o'clock the hay should be raked up into semi or perfect circles, and, before sunset, made into grasscocks. The business of the second day commences with tedding all the grass mown early in the morning, as soon as the dew is off the ground; the grasscocks should then be shaken out into what are called straddles or plats, each of about a perch and a half or two perches in breadth; between each of these a vacant space should be left to admit of the hay being turned toward either the upper or the lower part of the meadow when it is moved at nine o'clock and at noon; toward evening it should again be brought into circular ridges, and before the sun goes down again made into grasscocks, which latter must, however, be three or four times as large as those of the preceding day. The same course of proceeding must be continued throughout the third day, and by that time, if the weather has been sunny and fine, this hay will be dry enough to be gathered together in one large heap, preparatory to its being carried off the ground. But if any appearance of moisture is perceptible in the heap, it must be shaken out again, and the hay once more spread over the ground, though not thinly as before, and suffered to remain until every particle of moisture is evaporated.

All the grass which is mown after the early part of the morning should be left in the swaths or sweeps in which it fell from the scythe until the following day, and then submitted to the process we have just been describing. Every morning the newly mown grass should first be tedded and spread about; then the heaps shaken out into plats—the small ones first, and then the larger ones; and, after this has been done, the labor must be divided among the whole of the operation. Until some portion of the hay has been stacked or stored up in the hayloft, the amount of work to be done will increase every day, and more hands will be required to accomplish it properly.

Hay thus prepared retains its green hue, its aromatic scent, and indeed nearly all its most useful properties; it only loses its aqueous portion, and does not experience fermentation. When an extra number of hands can be procured, and the weather is favorable to the performance of the operation, equally as much is gained by the advantages arising from the work being expeditiously performed as is expended in the wages of the additional laborers; and, on the whole, the expenses are but little greater than they would have been had the operation been performed in an imperfect and dilatory manner.

Some farmers suffer the grass to remain on the spot where it was dropped from the scythe for two or three days before they begin to move it. There cannot be a doubt but that much labor is thus saved, because the grass, having become faded, dries much more quickly; but the hay thus produced is never so green.

When the weather is rainy, damp, or changeable, the hay cannot be so rapidly prepared. The chief point to be aimed at in this case is that of keeping the cut grass as much together as possible, in order that the water may not wash away its succulency, and yet to give it sufficient air; every moment of fine weather must be taken advantage of to move it about, otherwise there will be danger of its fermenting. So long as the grass continues green, retains its succulency, and, in a manner of speaking, its vitality, so long the humidity which falls from the atmosphere will not do it much harm; and when rainy weather sets in immediately after the commencement of the mowing, or the operation has been begun during rain, but in the anticipation of fine weather supervening, in either of these cases the grass should be left just where it was cut, until the weather is more favorable; should it, however, be too much pressed down by the moisture, it must be gently raised with a rake, and then it may be suffered to remain a long time in this state without there being any danger of its deterioration, provided, however, that there is no stagnant water on the ground. Wherever this last named evil exists, the whole, or as much as possible, of the grass must be removed to the highest parts of the meadow. Rain is most injurious to hay when it has lost its vitality and is partly dry; it then actually deprives it of its most nutritious particles. Hence it will be evident that great care should be taken to prevent the hay from being rained upon while it is spread out over the ground to dry; so soon as there is the least threatening of a shower, all the grass should

be gathered together and the driest parts made into heaps. When this precautionary measure has been taken, the hay will bear a continuance of heavy rain without suffering much deterioration, especially if the temperature is not very warm. The external part of the heap alone loses color and flavor, the interior portion remains green and retains all its succulency; and when the weather clears, and the hay can be spread over the ground, one dry day will frequently suffice to render it fit to be stacked in case more rain is anticipated.

When the wet weather continues for a considerable period without intermission, air must occasionally be admitted into the heaps or cocks; and care must be taken that the hay does not become heated. Should this misfortune be produced by the warmth of the temperature, the best way of managing this half-dried grass is that recommended by Klapmeyer, which we shall speak of more fully when we come to treat of the getting in of clover crops: it consists in uniting it all in one large haycock, in order that it may be equally heated throughout; subsequently shaking it out, and spreading it over the ground; and then, when it has become dried by the air, collecting it afresh. When it has once become overheated, it will not do so again; its color and smell changes, but it will not turn mouldy or contract any disagreeable flavor, and will always be adapted for the feeding of cattle. It will, of course, be understood that this mode of haymaking ought never to be practiced upon natural meadows, unless in cases of absolute necessity.

There is another way of making green hay, which saves a great deal of labor; this is but little practiced, although highly to be recommended. I shall now describe the details of the operation.

As soon as the grass is thoroughly freed from moisture, it is put, while yet green, into narrow heaps, which are made as high as possible; and, to prevent these from falling down, a small stake is driven into the ground, around which the grass is carefully arranged with the hands. A handful of grass is then taken from one of the swaths, and the longest and strongest portions are chosen from it to cover the top of the heap or haycock with, care being taken to turn the upper or flowering part of the grass downward. These pyramidal heaps are then suffered to remain until the grass of which they are composed is thoroughly dry, which is generally somewhere between the eighth and fifteenth day; on the heap being opened, the grass in the interior of it will be found to retain its hue and freshness. I have seen grass thus made into large heaps, during dry and windy weather, which has dried very rapidly without requiring to be moved, and has been quite green. Temporary rain or showers will not do it any harm, beyond that of depriving the external part of some portion of its color; but, should the wet weather continue for any considerable period of time, there is a possibility of the hay becoming too much compressed: it will then be necessary to open the heaps, and shake and loosen the hay, in order to prevent it from acquiring an unpleasant flavor.

There are some meadows, the greater part of the herbage of which requires to be exposed for a short period to both wind and rain, in order to get rid of its injurious properties, and render it agreeable and profitable to cattle. This is the case with all the large and hard grasses—not only the reeds and rushes, but also the blue hair grass (*aira cerulea*), a plant which is so often found on damp, low ground. It has been observed that cattle which are fed on hay containing a considerable portion of this plant, lose their strength when the hay has not been exposed to the air and warmth for a proper period. Such hay should be left upon the ground for five or six weeks, in order that it may be repeatedly wetted and dried again.

Brown hay is made by allowing the grass to remain for a day or two, or, if the weather is unfavorable, for even a longer period, where it was cut; afterward, when it is dry, it must be shaken and turned, and subsequently formed into small heaps. When it has remained thus for some days, these heaps are united together, so as to form larger ones. These, also, are left standing for some days; after which period the hay is collected and formed into large cocks. There it becomes heated, perspires, dries again, and eventually becomes like a block of peat. During this process, no air should be suffered to come in contact with the hay; and, instead of shaking and moving it, it should be compressed as much as possible, in order to exclude the air; for, wherever this is not attended to, putre-

faction and mildew will be engendered. This kind of hay, which is seldom stored in lofts, but made into cocks and ricks, may, when required for use, be cut with a knife, sharp spade, or hatchet. In many countries the farmers are greatly prejudiced in favor of brown hay, and assert that it forms a far better fodder for cattle than green hay does; in support of which assertion, they narrate various experimental trials made with the latter, all of which have turned out unfavorably. But, if we come carefully to examine into both sides of the question, we shall find that, in those places where the preference is given to brown hay, the green hay is almost always carelessly or imperfectly made; in which case there can be no doubt but that the former will be preferable. There are many recorded experiments which satisfactorily prove that good green hay is decidedly the most nutritious and advantageous, whether employed as fodder for horses, sheep, or milch cows; oxen only which are put up to fatten thrive best on brown hay.

Various instruments have been invented, with a view to diminish the manual labor of haymaking on extensive meadows, and by means of these a great portion of this operation may be executed with the addition of horse power.

Bloys de Treslong, in "The Acts of the Rotterdam Society," vol. ii. p. 88, describes a harrow which is made use of to turn the hay, and submit it more perfectly to the action of the air and the sun's rays. This instrument is composed of two pieces of wood, each nine feet long; and in each of which there are seven long teeth, made either of wood or iron. These portions are united together by three cross-pieces of about four feet four inches long. A horse is harnessed to the instrument on which a man or a boy mounts, and guides it up and down the meadow, by which means the whole of the hay is moved and turned over. This invention is, however, only useful in fine, dry, windy weather. It may easily be supposed that the hay thus made is equally dry and no way inferior to that formed in the usual way, although considerably less manual labor has been expended on it. A second laborer must always follow the harrow in order to raise it up when the hay becomes collected between its teeth.

A horse-rake may be made use of for the purpose of gathering the hay together from the sweeps or swaths in which it was cut, a similar instrument to that which is usually employed on the stubble of cornfields; and a haysweep is frequently used to accumulate the hay in heaps, to each extremity of which is attached a cord or chain, the other end of which is affixed to the harness of a pair of horses. On each side of the tree or piece of wood which forms the sweep, a man gets up who holds by a cord affixed to the reins, and bends slightly forward. The horses are then put in motion, and the hay is gathered together in front of this machine so quickly and thoroughly, that if the meadow is tolerably even, only a few stray bits are left here and there on the ground. When the laborers think that the heap is sufficiently large, they spring to the ground, still, however, holding by the cord; and the tree being no longer borne down by their weight, slides over the heap of hay. They then remount and proceed. This operation cannot be well performed, unless the persons employed are skilled in it.

Mr. Middleton, an Englishman, has given a description of a similar but much more complicated instrument, which account has been translated into German by Leonhardi, and published at Leipsic in 1787.

The carting and carrying of the hay are operations which are always executed much better and more promptly when the persons employed are accustomed to the work. As the bulk of hay is always very great in proportion to its weight, much nicety and skill are required in making the load such as a team can draw without difficulty. Therefore, a person skilled in loading hay, whether male or female, should always be selected for the performance of that work and encouraged. Neither must this operation be too much hurried, but time allowed for the hay to be divided and spread out in even layers, so as to maintain the equilibrium of the whole. Much more time is actually gained by proceeding gradually and surely, than by acting with precipitancy; for it is impossible for the person employed in loading to execute his share of the labor properly, if more hay is presented to him at once than he can possibly arrange.

In general, a relay of wagons is required, and the operation always progresses more rapidly when there is a pair of horses or oxen which can be made to draw the wagon that is being loaded, from one heap to another. The wagon ought

always to be placed between two heaps in order that it may alternately receive hay from either side, unless there happens to be a high wind, in which case it must be so placed that the wind shall blow the hay toward it.

The first thing to be done is to establish a due proportion between the number of laborers employed in loading, unloading, and stacking, and the number of teams and wagons. This proportion, however, must be regulated chiefly according to locality, and, therefore, merely general rules can be given for determining it. Every thing should be arranged so that one part of the operation shall not be retarded by another; that nobody shall be idle, and yet that nobody shall be too much hurried.

The back of the wagon must always be carefully fastened up and finished off, in order to prevent any hay from being lost on the road.

The hay, when properly made, is either stored in boarded lofts or granaries situated over the stable, in which the cattle are kept that are to consume it; or else it is formed into stacks, ricks, or cocks.

In storing it up, care must be taken that it is spread out in uniform layers, and piled together so compactly that no vacant spaces shall be left; for mildew is invariably engendered by such vacancies, and the moisture produced when the hay becomes heated also collects there. Where this is the case, the hay sometimes becomes so much heated as to give out vapor; and then, so far from loosening it, or lifting it up and giving it air, we must, as far as possible, endeavor to prevent the least breath of air from coming to it, and close up the shutters and all the outlets of the loft. Under these circumstances, the hay may ferment very much and turn brown; but it will not be spoiled, nor will there be so much danger of its taking fire. It is only when a free current of air is allowed to come to it that the inflammable gas, which under such circumstances is evolved, will be likely to take fire. We must not, therefore, touch the hay, unless it is to take it quickly out of the loft to cool and dry it again.

If the hayloft is thatched with a good straw roof, the hay must be piled as near to that roof as possible, and pressed down so compactly that no interstices shall be left between the two. When no portion of the hay is in contact with the air, it goes through its heat without receiving any damage, and every portion retains its quality and nutriment. Where the roof is of slates or tiles, the upper layer of the hay is very apt to lose its flavor, and become damp and mouldy.

It is well known that if we would have fodder preserve its good qualities, and not acquire a flavor and smell disagreeable to cattle, we must prevent all the vapors and miasma of the stable from penetrating through the floor into the stored hay situated above.

Arched floors, composed of boards covered with straw or reeds, are best adapted for preserving the store of fodder destined for the cattle beneath.

When distributing the different kinds of fodder in the granaries and lofts, great care must be taken to apportion to each variety of animals the kind of fodder which will be most agreeable to their palate, as well as beneficial for them; and to distribute the different kinds of hay through each loft in the order in which they are to be consumed, so that there may be no difficulty in getting at each one as it is wanted.

But it is far more advantageous to stack hay than to keep it in lofts or buildings of any kind. When the haycocks or stacks are properly formed, the hay will be preserved much better and in a more wholesome state than it ever can be in confined buildings, because those vapors which exhale from it, and which are so apt to engender mildew and an unpleasant flavor, are carried off by the air as soon as they reach the surface of the stack. This is the reason that, in England, farmers and dealers in hay and straw always assert that they can distinguish housed from stacked hay by the smell; and also that the latter is so much preferred, and will always fetch a much higher price. Each kind of hay should be made into a separate stack, as the farmer will thus be enabled to select that which he thinks proper for use; and will also be better able to keep the hay from one year to another. Hay and fodder stacks are sometimes built upon a floor or ground-work, formed for the purpose of stones or boards, or, what is still more common, on a bed formed of dry branches and straw; but an elevated and dry spot should always be selected for the site of a hayrick. On one of the foundations just mentioned, the fodder may be spread out by armsful, and ar-

ranged in regular beds, one above the other, each trodden down and compressed as much as possible. From the base up to a certain hight, the stack should continue to swell out and enlarge in circumference, and then gradually diminish until the eaves or summit assume the form of a roof, terminating in a point. Lastly, this roof should be covered with straw, for the purpose of protecting the hay, and carrying off the water and rain without its doing any injury to the stack.

Haystacks are made in various forms; sometimes they are round, at others square, but their most general form is that of a long square or oblong. This latter is usually preferable, because the stacks which are built in this way may be lengthened at pleasure, and all the crops of the year formed into one large stack, should such a course of proceeding appear to be advisable. One of the gable ends should be directed toward the north-west, or that point from which most wind and rain may be expected, in order that the least surface may be presented to the action of the elements. The surface of the top must be arranged at this gable end in the form of the slope of a roof.

When a stack is finished, all its roughness should not only be taken off with a rake, but the sides should also be carefully and evenly cut. If any hollows or inequalities appear—a circumstance which should, however, be as much as possible avoided—they must be carefully filled up, in order that no moisture may find a way in. Lastly, the stack should be covered up with straw, and a trench dug all round it to carry off the dripping of the water.

The long stacks have one great advantage over all others, namely, that the hay may be easily cut from them when required for trussing or for consumption, provided that it is cut off perpendicularly, and on the opposite side to that quarter whence most wind and rain come. The hay and fodder stacks should all be placed in one yard or enclosure set apart for the purpose, and surroundad with fences or walls: it is much easier to watch the progress of the consumption of the winter stores when they are thus placed, than it is when they are laid up in granaries, and consequently the farmer is enabled to regulate the expenditure of food according to the stock in hand.

Those floorings of boards or planks intended to serve as the basis of hay-stacks, and which are united with a movable roof that can be raised or lowered at will, are now scarcely ever made use of, being not only expensive but very inconvenient; and the hay being equally as well, if not better, preserved when exposed to the air. Those tunnels or tube-like vacuums which it was formerly customary to leave in the center of every haystack that was built, for the purpose of carrying off the vapor engendered in it, are now quite abandoned; for experience has proved that the portions of hay nearest to them were always the first to spoil.—Indeed, fodder can never be more effectually preserved from injury than when all communication with the open air is entirely cut off, and every approach to a vacuum avoided. The inconvenience of these tunnels, and the difficulty of forming them, are also arguments against them.

The haystacks or ricks, which are formed in meadows at some distance from the house, and are usually placed upon a raised scaffold or frame, when these meadows are liable to become covered with water during the winter, are generally very carelessly made; nevertheless, they turn out, on the average, exceedingly well. In countries where there is a great deal of meadow land, and where the chief part of the hay is made expressly for the purpose of being sold, these temporary ricks or stacks are very much used; there will not, therefore, be any occasion for us to enter into any minute description of them. They are to be considered merely as the means of meeting an exigency, and not in the light of permanent stacks.

Those persons who have tried the effect of forming their hay stacks of alternate layers of the straw of the spring corn which was left from the preceding year, and hay, have spoken very highly of the practice. They chiefly recommend it upon this ground, viz.—that the fodder can be compressed, even when not perfectly dry, as the straw will absorb all the humidity proceeding from the hay. The straw becomes impregnated with the flavor of the hay, and is thus rendered more agreeable and palatable to cattle, and is, consequently, eaten by them more willingly. This practice has chiefly been applied to clover hay; we shall, therefore, recur to it again when treating of that crop. Some agriculturists have recommended that the hay should be salted while being stacked, espe-

cially if it has at all suffered from the effects of wet or bad weather, or has contracted any unpleasant flavor; and they assure us that by attention to this salting process, the hay will be rendered exceedingly palatable to cattle. I have not as yet heard of any decisive experiments having been made on this subject; there is, however, little doubt but that the practice might prove advantageous where salt is tolerably cheap.

A distinction is made between hay properly so called, or the produce of the first crop of grass, and the aftermath, or grass which constitutes the second crop; and where the meadows are particularly fertile, there is also a third class of hay, or that arising from the third crop of grass.

The manner of making and preserving the hay of the second crop differs in no essential particular from the same process when applied to the first, except as regards such modifications as are rendered necessary by the advanced state of the season, or the difference in the weather and temperature. In order, however, to prevent such hay from igniting and taking fire while in the stack, it must be allowed to remain in the swaths upon the ground for a longer period before being moved, in order that it may become perfectly dry, for the moisture is not so easily and rapidly evaporated from the second crop of grass as it is from the first, or that cut in the earlier part of the year. On this account it is desirable, previously to its being spread out and turned, to suffer it to lie in the swaths as the mowers have left it for several days, in order that its vitality may be completely destroyed.

When the second crop of hay can be got in thoroughly dry, and has been grown during fine, warm weather, it is even more nutritious than the hay of the first crop. We shall speak of the use of hay when we come to treat of the management of cattle.

THE VARIOUS KINDS OF PASTURES.

In a previous chapter we have already pointed out the advantages attendant on the stall-feeding of horses and cattle; undeniable, however, as these are, it frequently happens that we are compelled to pasture the cattle, either because the circumstances of the establishment require it, or because the nature and situation of certain pasture-grounds prevent them from being otherwise rendered available. But, wherever any considerable number of sheep are kept, pastures are quite indispensable; for, although it has been shown, by undoubted experiments, that sheep may be fattened in enclosures on grass cut and carried to them, yet the general introduction of this practice would be attended with many inconveniences and difficulties, which we shall have occasion to allude to by and by.

The estimate, valuation, and cultivation of pasture lands, as well as the methods of turning them to the best advantage, constitute, therefore, an important branch of agricultural science.

The several kinds of pasture ground are thus distinguished from one another:

(*a*). Lands devoted alternately to pasture and tillage. Those portions of the arable land which are chiefly devoted to the produce of corn, but which, nevertheless, are from time to time laid down as grass land. To this class belong—

1. Pasturage on the unemployed portions of land subjected to the system of alternate tillage and pasturage, and that on land which bears a crop of corn once in three, six, or nine years only.
2. Pasturage on fallow ground.
3. Pasturage on stubble fields.

(*b*). Spring and autumn pasturage on meadow land.

(*c*). Extra pasture lands: those, the soil of which is at the same time mainly devoted to a different use, the pasturage of cattle not being the chief produce derived from them.

(*d*). Permanent pasture lands: or those which are constantly and exclusively devoted to the growth of herbage, and the pasturing of cattle.

These pastures are in general private property, or at any rate under the sole control of the lessee; but at times various individuals possess rights over them which totally nullify the value of the land to the farmer. We shall first consider pasture grounds as private property, and, subsequently, as under the control of various individuals.

It is customary to value pasture ground by calculating the number of cows which can be fed upon it during summer; the number of head of other kinds of cattle which such land is capable of sustaining may subsequently be determined by calculations deduced from the first estimate. Three acres of ground are usually allowed to be the extent required for the support of a cow.

A horse requires four acres and a half; a draught ox three acres and two-thirds; a colt two acres and a quarter; a sheep three-tenths of an acre; a pig three-tenths of an acre; a goose one-tenth of an acre.

These proportions are, however, liable to variations arising from the breed or size, or peculiar properties of the different kinds of animals, and also upon the amount of nourishment which certain varieties require; in places where sheep are scantily and badly fed it is usual to reckon fourteen of these animals as equivalent to a cow when calculating pasture ground; while, on the other hand, in those situations where the farmer attaches great importance to the nature and breeding of his sheep, he only allows eight to each cow.

But before we proceed farther, it will be as well to understand exactly what is the extent of pasture ground which should be allowed for each cow. A cow belonging to one of the large breeds of cattle, such as are found in the low countries, requires four times as much pasturage, if not more, than would suffice for the keep of a cow belonging to one of the smaller breeds, such, for example, as those which are found in hilly countries, where the soil is poor. Neither of these extremes must, however, be taken as the basis of our calculation; we must select one which is of a moderate size, and adapted for grazing on portions of land laid down to grass on a farm conducted under the system of alternate tillage and pasturage. A cow of this description will weigh about 450 lbs. while alive, and yield 250 lbs. of butcher's meat when dead. If allowed sufficient pasturage, she will annually yield about 80 lbs. of butter. The extent of pasture ground on such a managed farm as we have just been speaking of, which a cow of this description will require, has been calculated with the utmost accuracy; and from that calculation may be deduced the proportionate extent of other kinds of pastures which will be required for the same purpose.

In order to be able to form an estimate of the luxuriance of the pasturage which will be yielded by a field or portion of arable land laid down to grass, in a farm subjected to the system of alternate tillage and pasturage, it will be necessary to take into account the following circumstances:

1. The fertility or richness of the soil, which is proportionate with the luxuriance of the corn crops which it yields.

2. Grasses do not, however, shoot up and flourish most where the crops of grain have been most luxuriant, for, although there may not be a shade of difference in the soil of two fields, one may, from situation, from being more wet than the other, or from various other circumstances, be less adapted for the production of herbage. The difference, however, is not actually so great as it appears to be, the fine and scanty grass being often more nutritious than the abundant and coarser herbage.

3. The fertility of pasture ground depends in a great measure upon the number of corn crops which it has been made to yield since it was manured, for every one of these tends to diminish the richness of the soil and its disposition to produce herbage.

4. A good deal likewise depends upon the time which has elapsed since that portion of land was previously left at rest. If seeds have been sown upon it, the grasses and herbage seldom spread or shoot up very much during the first year; indeed, the plants which have been sown, which are in general Dutch clover, pimpernel, and ray-grass, scarcely make their appearance above ground during the first year. On ordinary soils, the pasturage is most luxuriant in the second and third years of rest. During the fourth and fifth years it usually diminishes in quantity; this is frequently occasioned by the growth of moss and weeds. This decrease depends, however, very much upon the condition of the land; for, on a rich soil which is in good condition and consequently favorable to the reproduction of herbage, this decrease is not perceptible; on the contrary, it has been asserted that the quantity of pasturage goes on increasing—an effect which may, in a great measure, be attributed to the quantity of dung deposited upon the soil by the greater number of cattle which it supplies with food.

At page 74, I have given the table in which Meyer states the extent of ground required for the keep of a cow at grass during the whole summer.

If six acres of pasturage or more are required for the keep of a cow during the summer, it is evidently by no means advisable to graze horned cattle: a soil of this description can only, therefore, be advantageously employed as pasturage for sheep.

In the rotation which includes alternate tillage and pasturage, the pasturage of those portions laid down to grass or rest constitutes a very essential item in the revenue, nor indeed can it be dispensed with, if we would maintain the harmony of the whole; therefore every means which should present itself of increasing the fertility of the pasture ground must be adopted; even at the seed time these important portions of the farm must not be neglected. In the old system of alternate tillage and pasturage, especially as it exists in Holstein, where this sys-

tem is carried on in all its primitive simplicity, the agriculturists did not like to till their ground or bestow a dead fallow upon it, because these operations tended to destroy the roots of the grass plants; and consequently, the land did not become so quickly clothed with verdure when left in repose. The value of the pastures was seldom lost sight of by them, and autumnal corn was usually the last crop sown previously to the field being laid down to grass, because herbage shoots up more abundantly among this description of crop; or, if oats were sown, the land was only plowed once for their reception, and that very superficially. It cannot be denied that this mode of proceeding was exceedingly proper, if the chief object which the farmer had in view was to favor the growth and increase of grass, and he was unable to discover any other means of attaining his end. It was a considerable period before any other means of raising fodder was generally adopted, for it was believed that the nutritious properties of natural herbage could not be adequately replaced by any plants artificially sown. This prejudice, however, no longer exists among intelligent and enlightened agriculturists, and it is now the general opinion that the herbage of a field sown with judiciously selected grasses, equals, if not surpasses, any natural pasture which can be met with.

Dutch clover is usually selected for the purpose of sowing land destined for pasture. The preference is given to this plant on account of the smallness of its seed; its tendency to propagate its plants by shoots or offsets from the roots; the facility with which its seed may be gathered, and the consequent low price at which it can be obtained. Two pounds of Dutch clover-seed are quite sufficient to sow an acre of ground, if evenly scattered over it. Purple clover is, however, frequently mixed with it, partly for the sake of obtaining a larger crop of hay, and partly because Dutch clover only thrives on soils which are in tolerable condition.

Ray-grass (*lolium perenne*) also answers very well when sown in conjunction with Dutch clover, as likewise does sheep's fescue-grass (*festuca ovina*). Both of these grasses form very thick and luxuriant pasture, and thrive well on high and hilly ground; there is little or no difficulty in gathering their seed, and, consequently, it is not expensive. From fifteen to twenty pounds must be allowed per acre, in addition to the seed of the Dutch clover. Some farmers state that they have sown woolly, soft grass (*holcus lanatus*) for the formation of pasture, and with very good effect. The seed of this grass is also easily gathered; it is true that there is some difficulty in getting it out of the pod or husk, but this trouble need not be taken where the seed is intended for home consumption, and not for sale. When sown in the husk, a bushel per acre must be allowed.—This grass always grows in tufts, and is particularly conspicuous toward autumn, at which season its radical leaves spread out vigorously. In my opinion, however, nothing but necessity induces cattle to eat it, and they leave it untouched whenever they can find any other kind of herbage. Besides, it is so easily destroyed by frost that no dependence can be placed upon it.

The pimpernel burnet (*poterium sanguisorba*) is an excellent plant for the formation of pasture, although as yet it is but little known among us; it will thrive upon very poor soils, where Dutch clover will not grow at all; it cannot, however, be denied that it yields a far more luxuriant herbage when sown on rich land. It retains its verdure even in the depth of winter, and in the beginning of spring shoots forth with the utmost vigor. It is particularly adapted for sheep, and these animals always eat it with avidity; it is agreeable to their palate, from its aromatic and slightly astringent properties. The seed of this plant may easily be collected from any portion of the field set apart for the purpose; it must, however, all be carefully gathered with the hand. On hilly and chalky fields, where the layer of vegetable mould is very superficial, quaking grass (*briza media*) will be found well adapted for the production of pasturage; sainfoin may be sown, in conjunction with this, with good effect on such land.

We shall again recur to this subject before the conclusion of the work.

We may, to a certain extent at least, include in the same class the pasturage on *outer fields* or *crop divisions*, during those years in which they are laid down to rest. My readers will remember that, when treating of the cultivation of grain, the above-mentioned term was applied to fields or divisions of land remote from the farm buildings, and more or less impoverished, and which, from want of manure, yield only one crop of grain in three, six, nine, or even twelve years.

It will be scarcely necessary for us to observe that the pasturage derived from land which is continually impoverished by crops of grain, and which receives no compensation, in the shape of manure or otherwise, for the exhaustion they undergo, cannot be placed in competition with that derived from corn-fields which have been properly manured, and then laid down to grass; the former are covered with small, weak, shriveled plants, and very often with nothing but goat's beard (*aira canescens*), knawel (*scleranthus annuus*), some of the smaller fescue grasses, and sweet-scented vernal grass (*anthoxantum odoratum*); the latter of which cattle will not touch when it is in an advanced stage of vegetation. Pastures of this nature are, therefore, rather to be regarded as places to which the animals may be turned for exercise than as actual pasture grounds for either sheep or swine; for, far from nourishing, they only impoverish these animals. The produce of such land can only be depended on when certain portions of it are low and damp, and, consequently, unfit for the production of corn; these spots become covered with coarse grass, and hunger compels the animals to browse on them; but as it frequently happens that, in such situations, the grass is dirtied with mud, the animals feeding on it are liable to be attacked with dangerous, if not fatal diseases.

If, on land subjected to the triennial rotation with fallowing, and which is only manured once in nine years, the eighth crop division, or field intended for the production of the spring corn, being no longer in a state to be sown with advantage, is laid down to grass, it may be safely reckoned on as pasture ground, since the soil will contain a tolerably large share of nutritious principles.

The pasturage derived from fallow fields, which, in the triennial rotation with fallowing, received the tillage bestowed previous to the sowing of the autumnal corn, is more or less luxuriant and abundant according to the degree in which the soil is impoverished, or the amount of manure which it contained at the period when it was plowed. The period for beginning to break up the fallow is, or ought to be, about the time of the feast of St. John; but some agriculturists find themselves compelled to postpone the plowing until later, in order to avail themselves of the pasturage for a few weeks longer. It is seldom, however, that the farmer is obliged to make any alteration on account of the rights which others hold over his land.

After it has been plowed, there is no longer any pasturage left for horned cattle, although sheep may still find a scanty picking over it even after the second and third plowings; but the operations of plowing and harrowing follow each other too closely to allow of this source of nourishment proving of any importance. No dependence can, therefore, be placed upon the pasturage thus obtained, at least for more than six or seven weeks; and at the season when this is available, vegetation is most luxuriant.

If the soil is in good condition, and well adapted for the production of herbage, this kind of pasturage may be estimated at about one-third of the value of the fields laid down to grass in the system of alternate tillage and pasturage, during their first year of repose; but where the soil is impoverished, the land must not be estimated so highly, for lands which are frequently submitted to the action of the plow produce less herbage than those which are laid down to grass for several successive years.

The pasturage on stubble fields, which commences immediately after the harvest has been got in, is more valuable on moist and badly tilled soils than it is upon those which are warm and well cultivated, and carefully freed from weeds; for the quantity of grass which grows upon the latter is but small. The principal advantage derived from them arises from the corn which falls upon them during the harvest: this corn is greedily eaten by pigs, sheep, and geese; which animals are, for this reason, the first that are turned upon the stubble fields. But this very circumstance renders the pasturage derived from stubble fields little adapted for horned cattle; it is only that derived from those parts which the other animals have left untouched, and where, in consequence, the grain which has fallen on the ground has germinated and produced young plants, which furnishes good pasturage to the larger cattle.

Among the various kinds of pasturage yielded by arable land, we must not forget to include that arising from the autumnal grain, both in the autumn season, as well as in the winter and spring.

This pasturage can only be derived in the autumn where the crops have been sown in good time, and have shot up with unusual vigor. It is more adapted for horned cattle than for sheep; indeed some persons assert that it is injurious to sheep on account of its richness. This pasturage is, however, it must be remembered, only available on fields which are well drained, and even then only in dry weather. Under opposite circumstances, it is frequently productive of great mischief.

It is, on the contrary, most adapted for sheep during the winter and spring seasons. There are various opinions relative to the advantages which sheep derive from it, and also as to the propriety of deriving all possible benefit from it, or abandoning it altogether. While some farmers rely chiefly upon it for the winter pasturing of their cattle, others think that the pasturage thus obtained, besides being very uncertain in its amount, only serves to make the sheep dainty, and causes them to reject the dry fodder which is afterward given to them in the stable; and, consequently, this variety in their food does more harm than good. In my opinion, it is those farmers whose chief object is to save their winter provender, who assign the greatest value to this kind of pasturage; while those who are fully aware of the advantages resulting from an abundant supply of dry fodder for sheep, either do not make any use of it, or attach a very trifling value to it.

We shall have occasion to recur to this question when we come to treat of the management of sheep. Still greater uncertainty exists with regard to the question whether or not this mode of feeding is injurious to the plants. Some agriculturists maintain that it is in the highest degree injurious; while others are of opinion that when adopted with proper caution, it is productive of good rather than harm. There cannot be a doubt that this mode of feeding cattle may be rendered exceedingly injurious to the corn. Several comparative experiments, conducted with the greatest care and attention, have tended to prove that the crop may be diminished to less than one-half the value of the seed; and even farther, if this system be carried out to the fullest extent, and the land left to the mercy of shepherds and herdsmen, whose only object is to obtain as much food as possible for the animals under their care. But, on the other hand, these same experiments have proved that good rather than evil results from this mode of feeding, when it is conducted with proper care and attention, and the following regulations are observed.

This kind of pasturage should only be made use of from the period of the commencement of the severely cold weather until the end of February; and not then unless the ground is frozen hard. Whenever the sun shines warmly, it should be no longer used excepting in the early part of the morning, or so long as the surface of the ground remains unsoftened by the sun's rays, otherwise the feet of the animals will sink into the soil and damage the roots of the plants.

The soil must also be perfectly free from ice and snow; for when it is at all covered, the animals keep scraping with their feet in order to discover the plants, and thus injure them and pull them up by the roots; neither must the sheep be left upon the corn-fields when they are covered with rime or hoar frost.

This kind of pasturage must never be attempted until the ground is well covered with the young plants; and on no account when they are only just beginning to show themselves.

Neither must it be resorted to at a more advanced season of the spring, or when vegetation has commenced, unless with very great circumspection, or in places where there is reason to fear that the crop will be too luxuriant, and that the grain, or the wheat especially, will be laid. In these cases, the animals may be suffered to graze upon the land to a later period of the spring, provided that the weather is dry. But this late pasturage must be used with great circumspection; and every point relating both to soil and temperature must be carefully taken into consideration. If all these points are attended to as they ought to be, it may be safely presumed that the dung of the sheep will restore to the soil quite as much nutritive matter as they take from it while grazing on the corn.

But where other persons besides the farmer hold a right over the land which entitles them to pasture their cattle upon it, the practice becomes highly injurious both to the land and to the crop; for the corn must then be abandoned to the

land and to the crop; for the corn must then be abandoned to the shepherds to do as they please with it, and they care nothing at all about the interests of the proprietor.

When treating of the cultivation of meadow land in general, I spoke of pasturage upon meadows. In the spring this pasturage is very beneficial to and well adapted for sheep, while in the autumn it is more suitable for cattle. When the farmer himself uses the land for this purpose, so far from its being injurious to the meadow to employ it as pasture ground, the practice tends greatly to improve it.

If other persons have a right over this pasturage, that is, if it be held in vassalage, the point of the greatest importance is to determine how late in the spring the animals may be left on the land, and how early in the autumn they may return to it again. These periods are usually fixed by custom or old documents. A difference in the duration of the right of spring pasturage, be it ever so little either one way or the other, makes a considerable difference in the value of the land to the person who rents it, as to him who holds the right of pasturage; and it is this which gives so much importance to the question, whether the right of pasturage should be continued until the 1st of May, *old* or *new* style; for during the twelve intervening days between these two epochs, the cattle which feed upon the land will, if the weather be warm, find an abundance of food; but they impede the growth and development of the plants, and consequently have an injurious effect upon the quantity of hay yielded by the meadow. I have already stated the extent of time in which, during the spring, cattle may be pastured on meadow land with advantage to themselves and the herbage.

Under the head of accessory pasture lands, we must first consider pasturage on wood-land. The value of this will depend not only upon the nature and situation of the soil, but also upon the kind, number and magnitude of the trees with which it is covered.

The more completely the ground is covered with wood, the scantier and poorer will be the herbage it produces; consequently, the pasturage will be less valuable, both on account of there not being room enough for the cattle to graze, and also because the herbage which grows in the shade is not so rich or nutritious as grass growing in other situations. Even where the soil is very fertile, and the grass shoots up luxuriantly under the trees, it has so little flavor and is so little agreeable to cattle that those animals which are accustomed to be well fed never touch it until compelled to do so by hunger.

Pasturage on forest land is generally productive of more harm to the forest than good to the cattle. Many very valuable forests have been kept in a most miserable state of vegetation by being subjected to this system; the young shoots and branches being destroyed and the old trees considerably damaged. Nor is this pasturage productive of benefit to the cattle; so far from it, it often engenders disease.

Instances may indeed be found in which the trees are sufficiently advanced in their growth to prevent the pasturage of cattle there from injuring them, and therefore the farmer may avail himself of this pasture with advantage, the more especially as the trees afford an agreeable shelter to the animals during very hot weather. But these cases occur but seldom, and it rarely or never happens that the trees remain uninjured when others besides the owner of the land hold a right of pasturage over it. With regard to the influence which different kinds of wood have upon herbage, it may be observed that the grass growing under pine trees is dry and scanty; that under firs and larches more valuable. Very good grass usually springs up under the shade of oak trees; the same may be observed with regard to the herbage found under beech and birch trees, where they do not grow too close together. The most luxuriant and abundant pasturage is usually found under alders, but these trees grow only in low and damp places, and the herbage growing in such situations is always unwholesome, and prejudicial to the growth of trees: all plantations of alders should, therefore, be thick and close enough to prevent cattle from entering them.

To forest pasturage appertains the fattening of pigs upon acorns and beech-mast. This fattening of swine is designated complete, three-quarter, half, and quarter fattening. The opinion generally entertained is that each of these pro-

portions is realized once in six years, and that three times the produce is a mere nothing.

In countries where Agriculture and cultivation generally are in a state of improvement, it is seldom, excepting under peculiar circumstances, which we shall immediately proceed to enumerate, that on farms of any size we meet with permanent pastures, or, in other words, land exclusively devoted to the growth of herbage.

The first exception is in places where the land produces such a plentiful supply of herbage as to make it valuable on that account, especially as the state of the locality, or the circumstances of the farm to which such land appertains, presents no more eligible means of turning the land to account.

The second is in places in which the raising of corn, and even the use of the soil as meadow land, is subject to many casualties in consequence of the frequency and danger of floods and inundations during the summer season.

The third exception is found on mountains and rapid declivities, where the nature and situation of the land and the climate would render it vain to endeavor to obtain any other kind of produce from it.

With the exception of these cases, almost all the land in cultivated countries which is held by individuals is subjected to the plow, and devoted either entirely or at alternate periods to the growth of various kinds of grass. It is only in places where a community of possession, or a right of service, presents obstacles to its being otherwise used, that good land which is worth the trouble of cultivation is still exclusively devoted to the production of herbage. And, in such cases, the pasturage obtained from the land is of very little value; for, generally speaking, none of the persons possessing a right over it concern themselves at all about improving or cultivating it.

The first of these three exceptions consists for the most part of pastures which, on account of the nutritious quality of the grass which it yields, is devoted to the fattening of cattle; for this reason such portions are designated *fattening pastures*, although they are often merely used for the grazing of milch cows and horses. The farmers who hold these pastures are perfectly aware that if the land was plowed up, and devoted to the production of the more valuable kinds of grain, it would yield a much larger return; but such pastures, as well as the nutritious matters which are contained in the soil, are usually regarded as heirlooms, which the farmer has received from his forefathers, and which he must transmit, as a sacred inheritance, to his descendants; and the man who dares to break one up, and appropriate to himself the advantages resulting from their tillage and cultivation, is looked upon as one who wantonly dissipates his own revenue, and robs his heirs. An extraordinary amount of fertility is attributed to these old pasture grounds; and it is thought that if they were to be broken up, and converted for awhile into arable land, they would never regain their pristine fertility, even though they should appear to bear as luxuriant a crop of grass as before. It is allowed that they will again put forth high and strong grass, but it is thought that they never afterward yield that thick, fine herbage which they bore in their primitive state.

I shall not pretend to decide how far this opinion is or is not well founded, but I find that it is maintained by a number of talented and unprejudiced agriculturists. But I think that where it has been deemed impossible to restore a thick, fine layer of grass, the failure has been attributable mainly to bad management: either the soil has been exhausted by being required to yield too great a number of crops, or else the attempt to restore it to the state of grass land has been badly conducted; perhaps the reproduction of grass has been left to Nature only, in which case it will not be restored for a considerable period; or, again, the kinds of grass sown may not have been adapted for the production of thick, fine, close herbage, the reproduction of which is the object in view.

In many countries, the fattening pastures have been subjected to an alternate rotation adapted to their nature: the advantages thus derived from them have been very considerable; and, during the years devoted to rest and pasturage, the produce yielded by them has supported a greater number of cattle than they were before capable of maintaining in two or three times that length of time.

To the second kind of pastures belong chiefly those situated near streams or rivers which are apt to swell and overflow their banks, or behind dykes or dams

constructed for the purpose of retaining these water-courses in due bounds.—These pastures, from being fertilized by inundations, are usually very rich and luxuriant. Their produce, and especially the pasturage to be derived from them, cannot always be depended upon; but in valleys, the arable land of which is situated on the elevated grounds, they are, and with justice, regarded as the basis of the whole establishment. Pastures situated on the sea-coast are still more valuable, salted herbage and salt marshes being regarded as so exceedingly beneficial to cattle.

The third kind, or mountain pastures, usually yield a very abundant crop of aromatic herbage, which possesses properties favorable to the secretion of milk. They are, therefore, peculiarly adapted for milch cows, which, during the summer, are left to graze upon them both night and day, and frequently at a considerable distance from the dwelling of the farmer; and it is not until the approach of winter that these animals are taken up into the stalls. To this class belong the celebrated pastures situated on the Swiss Alps, as well as those of the Tyrol.

Other high grounds of difficult access, which cannot be reached by the plow or by wagons, and producing thick but not strong grass, may be advantageously devoted to the feeding of sheep. In order to preserve to such pastures all their fertility, they should be suffered to retain all the dung deposited over them by the animals during the night. With the assistance of this amelioration, the pasturage will continue to improve; but, without it, it gradually becomes impoverished and covered with moss.

It is seldom that we now find land, in the occupation of one individual only, which is constantly devoted to pasture, when, from its nature and situation, it is capable of being converted into arable land that will yield a fair amount of produce; for it has long been the opinion of most persons that land of this kind yields a greater profit when it has been constantly subjected to tillage, or when the action of the plow has been made to alternate with rest in the state of grass land. All the permanent pastures which we now meet with are commons, or lands subject to certain privileges or liabilities which preclude the use of them for any other purpose. These common pastures are, for the most part, in a wretched condition, because every one is desirous of getting all he can out of them, and no one thinks of contributing to their cultivation or improvement.—When they are easy of access, and particularly when situated in the neighborhood of houses, they are used to excess at all times and seasons, and all kinds of cattle are turned on to them without any regard to proper order or succession.—Under such management, they afford little more than exercise ground for the animals, yield a scanty crop of herbage, and soon become completely impoverished. It has long been a recognized fact that little or no advantage is to be derived from such land, and, consequently, the propriety of dividing it has been seen and acknowledged. In some cases, those who held a right over the land have taken possession of it and tilled it, with the consent of all the other parties. Sometimes the landlord, and at others the lord of the manor, has taken upon himself the right of dividing this common ground among new tenants; and thus, during the last few centuries, the extent of common pasture land has become very much diminished. But, however advantageous this may appear to be to Agriculture in general, it is nevertheless certain that the diminution of pasture ground for cattle has been injurious to the cultivation of land, when the system or rotation under which the land is managed has not been altered to suit the change caused by this circumstance. It cannot be denied that, in former times, the generality of farms and agricultural establishments were better able to maintain themselves than they are at present.

Recent experiments made to test the success of the division of common pastures have tended to support this theory, so far, at least, as regards those cases in which, when the division was made, no new measures were taken as regarded the rotation by which the cultivation of the arable land was regulated. Each individual broke up the portion which fell to him in the division, and obtained from it as many crops as he could before it became exhausted. An increase of arable land demanded an increased supply of manure to ameliorate it; instead of which the supply was decreased, in consequence of there being no means of making up for the portion of pasturage thus lost. The fertility of the arable land, and the quantity of produce yielded by it, therefore diminished in proportion as

this land was increased in extent. Consequently, it behooves us to pause before we determine on dividing common pasture land into separate portions, without combining this division with that of the whole of the land, the suppression of all the liabilities by which the property is restricted, and the establishment of a new system of rotation, viz. either *alternate tillage and pasturage* or the *stall-feeding* of cattle. Where this cannot be done, it is undoubtedly far better for the welfare of the community that the common pasture grounds should be retained, measures being, however, taken to improve their cultivation and to ensure from them the greatest regular amcunt of produce that they can be made to yield.

The following are the principal regulations which must be attended to in the management of pasture land:—

They must be entirely freed from stagnant water which may exist in any part of them, rendering them marshy; for marshy and damp ground is very injurious to cattle of all sorts, and especially to sheep. The ditches and trenches—both those which are intended to be permanent and those which are only temporary—should always be kept open and in good repair.

If it be the object of the farmer to obtain the utmost possible amount of produce from their pastures, he must take care to destroy all the mole-hills.

Care must be taken to eradicate all the weeds, both those which are hurtful and poisonous, and those which take up a great deal of room, and prevent the growth of other and more useful plants. Thistles in particular multiply with great rapidity in rich pastures, for cattle will not touch them, and, consequently, their seed ripens and takes root. The cattle not only abstain from touching the thistles, but even abstain from eating the grass which grows around them. Pasture grounds may, therefore, frequently be seen completely covered with these noxious plants, and thus reduced to a comparatively useless state. This evil is, however, easily remedied; all that is requisite to be done is to cut down the thistles occasionally with a scythe, especially during the flowering season. When this is done several times following, these weeds will eventually disappear; besides, cattle will eat them after they have been laid on the ground and withered. In this manner the milk-thistle, henbane, and other noxious plants, may be eradicated. Finally, it is very advantageous to pastures to spread the dung voided by the cattle equally over them. If the dung be left undivided as it falls from the animals, the plants which it covers are at first completely stifled; but in the following year tufts of strong, coarse grass shoot up, which the cattle never touch, unless absolutely compelled to do so by hunger. But where the dung is properly divided and spread about, it produces a uniformly good effect on the vegetation, and that flavor which is so distasteful to cattle is scarcely perceptible. Shepherds are sometimes allowed to collect the dung voided by the cattle, and sell it; but by this means pasture is deprived of a great portion of the nutrition which properly belongs to it, and, consequently, becomes impoverished.

In using pasture ground, it is, moreover, necessary not to crowd them with a greater number of cattle than it can properly and advantageously support. When too great a number of cattle are turned upon the pasture, vegetation is checked; the plants have not time to attain their full growth; the cattle bite off the tops of them, and then tear them up by the roots. On the other hand, it is equally injurious to a pasture for too small a number of cattle to be turned on it to graze. The effect of this is not only to diminish the utility of the pasture and the return that it yields, but tends to impoverish it. Under such circumstances, the herbage shoots up in great luxuriance, and many plants appear which the cattle will not eat after they have attained any hight. These plants become strong and multiply; while the finer kinds of herbage, those best adapted for pasturage, disappear. Besides, if the pasture be not supplied with a proper number of cattle, it does not receive as much manure as it ought to have.*

For the same reason, the cattle must not be turned into the pastures too early in the year, or kept there too late.

It is certainly advantageous to pastures to remove the cattle from them now

* When the pasture is large in proportion to the number of cattle which graze upon it, and is not divided into separate parts by fences, the animals wander all over it, and destroy more herbage with their feet than they consume. By this means the vegetation is always checked. This inconvenience does not exist to so great an extent where the number of cattle is properly proportioned to the size of the pasture, or where it is divided so that as soon as they have grazed off one part they may be removed to another.

and then, in order that the grass may have time to recover itself. It is for this reason, that in the best conducted agricultural establishments, and those in which pasturage on the arable land forms a constituent, if not an important part of the rotation, the pasture ground is divided into separate parts. Under such an arrangement, the animals which require the most succulent and nourishing food are first turned on to each separate division; and, after they are removed, the other kinds which need a smaller quantity of nutriment are turned on to it. By this means the whole of the grass is eaten off close to the ground, and thus those plants which the cattle are least partial to are not able to grow. The herbage is then left to recover itself for a sufficient time, and afterward the first herd is again allowed to feed upon it.

The succession, association, or separation of the various kinds of cattle upon pasture land, is in a great measure regulated by local circumstances.

In the spring, the best pasturage is often given to the ewes, because these animals stand in most need of it to increase their supply of milk, and give them strength to nurse their lambs. If the winter stall-feeding of the large cattle can be prolonged until late in the spring, it will be rather advantageous than otherwise. For experience shows that herbage always grows most thickly when sheep have been suffered to graze upon it early in the spring; but they must not be left too long upon the pasture, and at least three weeks must be allowed to elapse before the larger cattle are turned on to it. By such mode of treatment, the grass will have time to recover itself; and the smell of the dung which the sheep have left on the ground—a smell exceedingly unpleasant to cattle—will have time to become dissipated. If, in the after part of the season, sheep and cattle are alternately turned upon the pastures, the same interval of time, viz. three weeks, must always be left between the occupation of the pasture by the one and the other.

It is not only upon badly managed pastures in which poverty and disorder are apparent, that sheep and horses are seen grazing by the side of cattle, but the same may frequently be observed on rich fattening pastures. It is a generally received opinion, that the grass which is too coarse and hard for cattle, and especially that which springs up in places where the dung has formerly fallen, cannot be consumed with greater advantage than by mixing horses with large cattle; while the very fine herbage, which the cattle cannot lay hold of with their teeth, is peculiarly adapted for sheep. As it is always deemed advisable that the grass should be eaten off close and uniformly, it is necessary thus to mix the kinds of animals on it; and where this has been done with due care, after a certain time the herbage shoots up again with increased luxuriance and thickness.

Some farmers, however, do not approve of the practice of turning horses on to the pastures before the cattle are removed, but let cattle, horses, and sheep succeed each other, and then leave the pasture alone to recruit itself.

The division of pasture land into separate portions, whether these portions are close together or situated at considerable distances from each other, and the practice of successively turning the different kinds of cattle on to these divisions, and then leaving the herbage to recover itself, is a system which possesses decided advantages over the practice of suffering the cattle to wander over the whole extent of pasture ground. Cattle which are always confined in small spaces, do not spoil so great a portion of the herbage with their feet as if they had more space to graze over. The grass is, consequently, uniformly eaten off from the whole of the ground, and then left to recover itself. But where the cattle are allowed to roam over a large extent of pasturage, some parts remain untouched, and there the grass grows old and hard; while from others the herbage is cropped so close that it can scarcely shoot up again. Cattle are more quiet in confined pastures, and quietness is highly advantageous to them.

In many countries, where pasturage forms part of the system or rotation, the pasture ground is divided into small enclosures, each of which receives a number of animals proportionate to its size; care being taken that the animals placed together shall be of about the same size and strength, and such as are accustomed to be together.

Great value is, consequently, set upon small enclosures bounded by hedges, because considerable importance is attached to the shelter which these hedges afford to the animals from wind, from excessive heat, from the rays of the sun, and

likewise to the greater degree of quiet which cattle enjoy in a space thus enclosed.

Good watering places are essential requisites in all pastures. The ponds or reservoirs, in which the drainage from springs and ditches is collected, afford but a poor resource to the cattle. Therefore, where there are no natural watering places, artificial ones must be constructed. These should be dug in situations where the water is disposed to collect, and to which that contained in the ditches can be conducted. They should never be placed close to the ditches, nor should these latter be enlarged for the purpose of bringing them near to the reservoir; for the edges of the ditches would, in that case, be spoiled and broken by the feet of the cattle, and they, themselves, choked with mud. The best way is, to conduct the water into the pond or reservoir through a ditch or trench intended for that purpose. These ponds, or watering places, should be at least seven feet deep in the center, and should slope gradually from the brink to this depth. Their circumference should be in proportion to the number of cattle for whose use they are intended: the mean diameter is usually about sixty feet.

When the soil is of a plastic nature, and especially if it be at all argillaceous, these ponds will retain the water very well; but if the soil is sandy, or contains beds of sand, which may admit of the water leaking out, it will not be sufficient to coat the reservoir with clay, as this is liable to crack; but the bottom must be covered with mortar made from lime, in the following manner:—The surface having been well smoothed and beaten, must be covered with a layer of recently slaked lime, two or three inches deep, sifted and moistened with water, until it becomes of the consistence of cream; on this must be laid a stratum of clay about six inches thick. This clay should then be beaten until it becomes as firm and hard as a paved floor.

Section V.

THE REPRODUCTION OF ANIMAL AND VEGETABLE SUBSTANCES.

Reproduction and manufacture are usually considered as somewhat synonymous terms; but we are of opinion that, whether viewed in a physical light, or with relation to general economy and art, these two things are so completely opposed to each other that the principles which are applicable to the one are altogether foreign to the other: and, consequently, the agriculturist, the manufacturer, and the political economist, must each be guided in their various operations by totally opposite rules and maxims.

There cannot be a doubt that these two things are of entirely opposite natures, and that each of them has certain peculiarities which appertain solely to it; but these peculiarities are not so widely different as some persons have pretended. In fact, those differences which have most frequently been pointed out will be found, when we come to inquire into their fundamental principles, to have but little foundation. It will not, therefore, be foreign to our present purpose here to say a few words respecting the analogy of these two modes of procuring matter, as well as on their differences.

The principles and rules which have been adopted as those best calculated to ensure success in the economy of manufactures have already been entered into and explained: they may serve as a guide to the economy of reproduction, if, from the resemblance between the latter and manufacture, there is any possibility of the same rules being applied to each of them. Some have asserted that the essential difference between manufacture and reproduction is that the former gives an unusual form to matter, whereas the latter produces fresh matter itself.

But reproduction is not a creation or formation of some substance made without matter. The elements for the formation, growth, and accomplishment or maturing of the plant or animal ought to exist first of all. Whoever wishes to ensure reproduction, must, like the manufacturer, procure the elements to work on; in many cases he must seek for them, and even give them an artificial preparation. Reproduction, as also fabrication, can only be made to take place with the assistance of substances which already exist, which become decomposed from their original elements, and are thus prepared to assume new forms.

It is said that formation is brought about in reproduction simply by the force of nature, while in manufacture the effect is produced by art and the power of man. But in this latter case man acts

only by employing the force of Nature, without the coöperation of which he can obtain but very few of the usual products of manufacture. In most cases, it is true that he directs that force, in a greater or less degree, according to his own will; but there are many existing circumstances under which he is compelled to leave Nature to act entirely to her own laws. This is the case in all those manufactories which are compelled to have recourse to chemical processes, as color makers, wine and brandy distilleries, breweries, &c.; operations in each of which we can only moderate, and endeavor to regulate the natural action which substances have upon each other.*

Is it, then, to be understood that Nature operates more powerfully in reproduction than in manufactures? Undoubtedly, if Nature has only to supply the wants and necessities of a small extent of surface. In a thinly populated country Nature can often produce sufficient, if we take into account all the collective produce of the soil, as well as the game found upon it, to supply the wants of the wandering and isolated hordes who seek their subsistence there; but this is only the case in those salubrious and fertilizing climates where the human species first originated. After man had been expelled from Paradise, he had, as the human race spread and multiplied upon the earth, to struggle with thistles and thorns, and to eat bread earned by the sweat of his brow, or, in other words, to have recourse to labor and art, in order to satisfy his wants: he had to procure from that highly favored spot and its environs, not only the most nourishing kinds of grain and vegetables, but also those domestic animals of which he stood in need, and to devote all his care and art to the naturalizing both of plants and animals in the new locality which he had chosen for himself. By degrees, as his necessities and his family increased, his faculties developed, and art and labor were rendered more requisite; so that at this period among civilized people, the share that labor and art had in the production of the mass of natural products, when compared with that which may be attributed to Nature, is not assuredly less than that which may be attributed to them in the preparation of manufactured articles. This fact contradicts the assertion which attributes to art and science a greater share in manufactures than it has in Agriculture.

By degrees, as reproduction augments in quantity and value, the man whose object it is to induce it, will have to submit to the same rules and laws as the manufacturer. However extraordinary, therefore, some persons may consider the theory which leads me to consider the soil as the agriculturist's primitive matter, at any rate, if it be wished to place Agriculture and manufactures in opposition to each other, I cannot renounce it, since, in my opinion, numerous and very important consequences result from this theory, not only as regards the development of industry, but also of political economy.

We approach nearer to the point of separation between manufacturers and reproduction, when we say, that with the assistance of science and labor the former represents the object under that form which has been designed for it, and according to some previously determined plan; while, on the contrary, he who induces reproduction is subjected to those forms from which Nature seldom or never varies, and although he may choose between them, he can never alter them. But even this is by no means an exact definition, for certain manufacturers are equally subjected to the forms prescribed by Nature, as for example, the manufacture of salt, and, in fact, all those in which crystalization takes place, or where chemical processes are employed. In such manufactures the form can only be modified, and this not precisely in accordance with the will of the manufacturer, but more in accordance with the action and processes of Nature.

* As we have in another place had occasion to remark, "No branch of chemistry is more interesting, even to the general reader, than that which relates to the vegetable world; for objects of the highest interest here present themselves in all directions. The finger of God seems evident in every plant we chemically examine. Thus, their juices, which are always so regular and so uniform—so sweet in some, so bitter or acid in others; tasteless in many, yet saline in several—the order and the regularity are alike incomprehensible to us. Neither by any contrivance of ours can this regulated order of things be altered. For instance, the wild sorrel still secretes its acid, if nourished with only sugar and water; the sea-kale, which grows wild on the sea-shore, will yet secrete in its juices common salt, when growing on our most inland gardens. Neither can a plant be made to absorb one salt in preference to another. If a sprig of mint is placed in a solution of various salts, it will absorb some, but entirely reject others.

The power which the plant thus exercises is to the chemist utterly unknown. To effect the same separation of the salts when dissolved together in water, the chemical analyst has to perform a series of decompositions, and other chemical operations, before the desired result can be obtained, a process which the sprig of mint performs at once. The reader must not suppose that this is the effect of mere filtration, for the most delicate filters are utterly useless in any attempt to separate a salt from its solution. Then, again, certain plants show a decided preference for, and absorb only, particular salts. The nettle and the sun-flower, for instance, saltpetre (nitrate of potash), clover, gypsum (sulphate of lime). And these absorbent powers of the plant are not confined to soluble substances, alumina, manganese, phosphate of lime, &c. which are not dissolved by water, abound in plants. And, moreover, the required substance seems always placed, by some magical and unerring arrangement, in the very part of the vegetable where its presence is most needed. Thus flint (silex) abounds in the straw of wheat, where its presence helps to impart the requisite degree of firmness to enable it to support the loaded ear; but it is found in a very diminished proportion in the seed, where it is not required. Is not this the contrivance of its Divine Author?—or is all this arrangement also chance? The progress of chemistry continually unfolds many a beautiful vegetable phenomenon just as mystic, just as astonishing as any of these, and the field is not yet nearly exhausted; but still the conclusion the chemist arrives at is the same. The deeper he penetrates, the more numerous are the contrivances he observes, and more clearly manifested become the works of the Creator. Examine as another instance of these mysteries merely a cubic inch of soil, composed at most of only four simple earths, and notice the discordant nature of the chemical ingredients so uniformly and so regularly produced by the different plants which that soil produces with only the aid of water, and the atmospheric gases. Observe the wheat producing its flour; the sorrel its oxalic acid; the beet its sugar; the poppy its opium. From one plant comes the fragrance of the rose; from another the odor of the garlic. Dr. Thomson thought of these things when he observed ("System of Chem." vol. iv. p. 303:) "The multiplicity of operations continually going on in vegetables at the same time, and the variety of different and even opposite substances formed out of the same ingredients, and almost at the same place, astonish and confound us. The order, too, and the skill with which every thing is conducted are no less surprising. No two operations clash. There is no discord, no irregularity, no disturbance. Every object is gained, and everything is ready for its intended purpose."

his land. It must not, however, be understood, that we mean to advocate the practice of saving the grain of those years in which the crops have not become properly matured; for then, as has already been stated, it is not fit for seed. But if, when such years occur, the farmer happens to possess a store of seed left from the preceding year, he may consider himself very fortunate.

It is of the utmost importance that the grain should be carefully separated from all those seeds of weeds which may be mixed with it, as well as from all the imperfect grains which may exist. This may be effected—

1. By winnowing the seed, or throwing it into the air (as is the practice in some countries, in order to separate the grain from the husk and the dust); the grain which has fallen farthest off is then chosen for seed. This operation may also be performed by means of a ventilator, or a kind of mill which separates the heavier from the lighter grain, and from the seeds of weeds.

2. By means of sieves, of which we must have a variety, pierced through with holes of all sizes; the seed of weeds is smaller than grain, and all the little abortive grains fall through the sieve, while all that is properly developed is retained. Seeds of a different class, and which are larger than the grain, must subsequently be separated from the latter, by means of other sieves which retain the grain.

3. By washing, throwing the seed into vats filled with water, in which they are afterward stirred about. All the heterogeneous matter, as well as those light grains which swim on the surface, are then removed. This is by far the best way of getting rid of the seed of the wild mustard *(sinapis)*, and that of several other weeds. Immediately after this operation, all the grain which has been immersed must be spread out to dry, if we would not have it sustain any damage.

This process must not be confounded with the practice of moistening the seeds, and then keeping them in a state of humidity, in order to accelerate the germination of them, and then burying them; this practice has long existed among gardeners. It has also been recommended that this mode of proceeding should be applied to arable land, especially when, at the sowing season, the earth is extremely dry. But I cannot deny that, in my opinion, it is particularly at this period that such a practice would be fraught with most danger; for, if the drouth should continue after all the moisture has evaporated, or been absorbed from the germinating seed, this latter, or the young plant it has produced, must necessarily become parched and die; therefore, it is far better for the seed to remain in the earth without germinating, until sufficient rain falls to impregnate it with moisture, and calls forth its vitality. It is true that, where moisture comes opportunely, the above plan may prove successful; for the seeds will germinate and shoot up much more rapidly than they would have done had they been put into the earth dry; but the advantage is not sufficiently great to counterbalance the risk; at all events, recourse should only be had to this practice when the sowing has been so much retarded that there is no longer any danger of the earth becoming so dry as to parch the seed.

Divers methods of heating or swelling the seeds have also been recommended, for the purpose of accelerating and strengthening the process of germination. We shall speak elsewhere of those, the object of which is to preserve the grain from smut and other diseases; at present we shall only occupy ourselves with those means which have for their object the stimulating or strengthening the principle of vegetation.

(*a*). The drainage from dung-hills, lime water, wood-ash water, salt water, &c., these being considered as active manures which place the young plants in direct contact with aliments peculiarly adapted to their nature, tend to accelerate vegetation, and give to these plants sufficient vigor to enable them advantageously to combat the injurious action of whatever may be around them.—But theory and unprejudiced experiments combine to demonstrate the inefficacy of manure which immediately surrounds the seed; for the young plant first derives its nourishment from the seed grain itself; and, when it begins to seek nourishment through the medium of its roots, the ramifications of these latter shoot out too far to admit of their receiving any nutriment from the substances which immediately surround the husk of the seed. These manures, when thus applied, are, therefore, productive of little or no effect; their quantity being too insignificant to produce any sensible effect upon the soil.

(*b*). Some persons have also recommended for this purpose divers substances which contain oxygen, and even some acids, particularly oxygenated muriatic acid, sulphuric acid, cinnabar, and other oxides of lead, sulphate of iron (green copperas), nitre (saltpetre), nitric acid, sulphuric acid, and arsenic. Many of these substances have been used for a considerable period, long before it was discovered that oxygen and those matters which from being surcharged with that acid easily separate from it, act as violent stimulants on the germinating properties of seeds; since that discovery, the attention of many scientific men has been directed to this point. However incontestable the fact may be, that oxygen possesses the faculty of accelerating vegetation, many carefully conducted experiments have shown, that this excessive stimulation of the germ of the young plant is far from being productive of benefit, but rather tends to predispose the plant to weakness and disease.

Both theory and experience incline us, therefore, no longer to advise the employment of these means, and especially as it is difficult to ascertain to what extent they may be used, and how they may be employed on an extensive scale so that each shall receive its due proportion.

Several agriculturists have endeavored by the use of these substances to keep off and destroy insects and birds; but the common steeps of this nature do not produce the desired effect; and it is dangerous to employ poisonous ones, particularly such as contain arsenic in sufficiently powerful proportions to ensure the attainment of the desired object.

Each separate kind of grain has a certain period of time, longer or shorter, during which it ought to lay in the earth in order fully to develop itself and ensure its producing perfect plants. The success of the crop very often depends entirely on a favorable time being chosen for placing the seed in the ground. But as the success of this choice depends upon the state of the weather and temperature during the period of vegetation, the farmer will never be able with certainty to determine the best time for getting the seed into the ground. He must be chiefly guided by the dry-

ness or humidity of the air and of the soil, and thus endeavor to select that state which he knows to be most favorable to each kind of grain. Rye, barley, and buckwheat require a dry and warm soil to favor their first germination: others, on the contrary, as wheat and oats, require more moisture. Much is already gained if only in this respect the favorable motion has been seized; and there will be a far more reasonable hope of the harvest being successful when the sowing has taken place under such favorable auspices, than there ever can be when it has been performed under different circumstances. It has often been remarked that certain states of the weather and of temperature are particularly propitious to the operation of sowing. In the spring, when the atmosphere is loaded with fogs, which, particularly at sunrise and early in the morning, give to the boundaries of the horizon an apparently undulatory motion, so that the rising sun appears, in the language of the people, "to dance." When this is the case, large barley may be sown with peculiar advantage. Many agriculturists attribute great advantages to the seed being brought in contact with the dew, and, consequently, recommend that the sowing should be performed toward evening, and the seed not covered until the following morning; but this can only managed when the nights are warm. If there is any danger of white frost coming on, the seed must be covered at once.

Many agriculturists give it as their decided opinion that the seed should be got into the ground at the earliest period at which the operation can be performed, and as quickly as possible. But by acting up to this maxim in the fullest extent of its meaning, we shall run the risk of sustaining great loss, especially if we neglect those considerations which have reference to the state of the soil and the temperature. In all cases, however, everything should be kept in readiness to embrace the first favorable moment. The English have a saying, "You had better be out of temper than out of season." What is chiefly to be avoided is the neglecting a suitable amount of preparation, from a desire to sow early.

Formerly the moon was supposed greatly to influence the period of sowing; certain seeds were to be put into the earth during the moon's increase, others during its decrease. The rules appertaining to this theory had almost been forgotten, when a skillful and experienced American gardener revived them by relating his own experience and experiments, and he brought over several Englishmen to his opinion. A natural philosopher seeks to explain the influence of the moon, by saying that the uninterrupted action of light which takes place when the moon shines throughout the whole night may possibly be injurious to plants during their period of germination, since it is a well known fact that light is not favorable to plants which are in this state. It will be advisable to wait until this system is confirmed by a greater number of facts and experiments before we allow ourselves to be at all influenced by it.*

Each kind of seed ought only to have a covering of earth of such a depth as is suitable to its nature. So long as this depth is not exceeded, there is no doubt but that the seed will shoot the better for being placed at a considerable depth below the surface, because it there finds the necessary moisture, and the young shoots which are given off from its roots, run less risk of being parched, deprived of earth, or destroyed by frost. But too thick a covering might very possibly entirely prevent the germination, or, at any rate, present too great an obstacle to the putting forth of the seminal leaves. As a general principle it may be admitted that the larger the seed the thicker is the covering it can bear; while very fine seeds will only bear a light covering of earth.

There are three methods of covering up the seed in agricultural operations:

1. By sowing under furrows, and burying the seed by plowing.
2. By sowing upon furrows, and burying the seed with a harrow.
3. By sowing in land which has been plowed and harrowed, and burying the seed by a second harrowing, or by passing a roller over it.

And to these we may add a fourth, viz.:—

4. By burying the seed with a drill, or some machine of the kind.

The depth at which the seed ought to be buried, and the choice of the manner of covering it, depend as much upon the actual nature of the seed, as upon the state of the soil and temperature. All kinds of seed require to be more covered in dry than in moist seasons. We must allow ourselves to be guided by this fact; carefully, however, avoiding all extremes, as it is possible that the temperature may change immediately after the seed has been sown; and then, if heavy showers should happen to fall, those seeds which have been placed deep in the earth will be very likely to be smothered. The drill, or a similar machine, is the best instrument which can be made use of for covering the seed, because it enables us at once promptly and securely to sow to a greater or less depth as seems best. In the course of this chapter we will consider the nature of each kind of seed. For the present we shall merely observe, that among the seeds in most general use, vegetables, wheat, barley, and oats require to be well covered; while rye and buckwheat, on the contrary, do not admit of being placed so deep in the earth: there is always great danger in sowing the latter under furrows when there is any possibility of wet weather ensuing.

Some agriculturists have, in order that they may proceed with more certainty, adopted the practice of burying one-half their seed under, and sowing the other upon the furrow. I do not consider that it is of much consequence as regards autumnal sowing, whether or not this method is employed; and it may often prove beneficial to the agriculturist to act upon it, especially if he is not inclined to devote much manual labor to the operation. But when it is applied to the spring sowing, the most deplorable results have ensued, because by means of it the seed is divided into two portions in point of vegetation, and this difference is perceptible even up to the period of its attaining full maturity.

It is always necessary to pay very great attention to the sowing of small seeds, such as clover-seed, for they may when covered by harrowing easily become too deeply imbedded in the earth; not that they require to be well surrounded with mould to ensure their germination, unless the weather happens to be extremely favorable. We shall return to the consideration of this subject when we come to speak of the cultivation of each kind of produce separately.

* See LECTURES ON SCIENCE AND ART, by Dr. Lardner, vol. i. p. 501 *et seq.*

his land. It must not, however, be understood, that we mean to advocate the practice of saving the grain of those years in which the crops have not become properly matured; for then, as has already been stated, it is not fit for seed. But if, when such years occur, the farmer happens to possess a store of seed left from the preceding year, he may consider himself very fortunate.

It is of the utmost importance that the grain should be carefully separated from all those seeds of weeds which may be mixed with it, as well as from all the imperfect grains which may exist. This may be effected—

1. By winnowing the seed, or throwing it into the air (as is the practice in some countries, in order to separate the grain from the husk and the dust); the grain which has fallen farthest off is then chosen for seed. This operation may also be performed by means of a ventilator, or a kind of mill which separates the heavier from the lighter grain, and from the seeds of weeds.

2. By means of sieves, of which we must have a variety, pierced through with holes of all sizes; the seed of weeds is smaller than grain, and all the little abortive grains fall through the sieve, while all that is properly developed is retained. Seeds of a different class, and which are larger than the grain, must subsequently be separated from the latter, by means of other sieves which retain the grain.

3. By washing, throwing the seed into vats filled with water, in which they are afterward stirred about. All the heterogeneous matter, as well as those light grains which swim on the surface, are then removed. This is by far the best way of getting rid of the seed of the wild mustard *(sinapis)*, and that of several other weeds. Immediately after this operation, all the grain which has been immersed must be spread out to dry, if we would not have it sustain any damage.

This process must not be confounded with the practice of moistening the seeds, and then keeping them in a state of humidity, in order to accelerate the germination of them, and then burying them; this practice has long existed among gardeners. It has also been recommended that this mode of proceeding should be applied to arable land, especially when, at the sowing season, the earth is extremely dry. But I cannot deny that, in my opinion, it is particularly at this period that such a practice would be fraught with most danger; for, if the drouth should continue after all the moisture has evaporated, or been absorbed from the germinating seed, this latter, or the young plant it has produced, must necessarily become parched and die; therefore, it is far better for the seed to remain in the earth without germinating, until sufficient rain falls to impregnate it with moisture, and calls forth its vitality. It is true that, where moisture comes opportunely, the above plan may prove successful; for the seeds will germinate and shoot up much more rapidly than they would have done had they been put into the earth dry; but the advantage is not sufficiently great to counterbalance the risk; at all events, recourse should only be had to this practice when the sowing has been so much retarded that there is no longer any danger of the earth becoming so dry as to parch the seed.

Divers methods of heating or swelling the seeds have also been recommended, for the purpose of accelerating and strengthening the process of germination. We shall speak elsewhere of those, the object of which is to preserve the grain from smut and other diseases; at present we shall only occupy ourselves with those means which have for their object the stimulating or strengthening the principle of vegetation.

(*a*). The drainage from dung-hills, lime water, wood-ash water, salt water, &c., these being considered as active manures which place the young plants in direct contact with aliments peculiarly adapted to their nature, tend to accelerate vegetation, and give to these plants sufficient vigor to enable them advantageously to combat the injurious action of whatever may be around them.—But theory and unprejudiced experiments combine to demonstrate the inefficacy of manure which immediately surrounds the seed; for the young plant first derives its nourishment from the seed grain itself; and, when it begins to seek nourishment through the medium of its roots, the ramifications of these latter shoot out too far to admit of their receiving any nutriment from the substances which immediately surround the husk of the seed. These manures, when thus applied, are, therefore, productive of little or no effect; their quantity being too insignificant to produce any sensible effect upon the soil.

(*b*). Some persons have also recommended for this purpose divers substances which contain oxygen, and even some acids, particularly oxygenated muriatic acid, sulphuric acid, cinnabar, and other oxides of lead, sulphate of iron (green copperas), nitre (saltpetre), nitric acid, sulphuric acid, and arsenic. Many of these substances have been used for a considerable period, long before it was discovered that oxygen and those matters which from being surcharged with that acid easily separate from it, act as violent stimulants on the germinating properties of seeds; since that discovery, the attention of many scientific men has been directed to this point. However incontestable the fact may be, that oxygen possesses the faculty of accelerating vegetation, many carefully conducted experiments have shown, that this excessive stimulation of the germ of the young plant is far from being productive of benefit, but rather tends to predispose the plant to weakness and disease.

Both theory and experience incline us, therefore, no longer to advise the employment of these means, and especially as it is difficult to ascertain to what extent they may be used, and how they may be employed on an extensive scale so that each shall receive its due proportion.

Several agriculturists have endeavored by the use of these substances to keep off and destroy insects and birds; but the common steeps of this nature do not produce the desired effect; and it is dangerous to employ poisonous ones, particularly such as contain arsenic in sufficiently powerful proportions to ensure the attainment of the desired object.

Each separate kind of grain has a certain period of time, longer or shorter, during which it ought to lay in the earth in order fully to develop itself and ensure its producing perfect plants. The success of the crop very often depends entirely on a favorable time being chosen for placing the seed in the ground. But as the success of this choice depends upon the state of the weather and temperature during the period of vegetation, the farmer will never be able with certainty to determine the best time for getting the seed into the ground. He must be chiefly guided by the dry-

ness or humidity of the air and of the soil, and thus endeavor to select that state which he knows to be most favorable to each kind of grain. Rye, barley, and buckwheat require a dry and warm soil to favor their first germination: others, on the contrary, as wheat and oats, require more moisture. Much is already gained if only in this respect the favorable motion has been seized; and there will be a far more reasonable hope of the harvest being successful when the sowing has taken place under such favorable auspices, than there ever can be when it has been performed under different circumstances. It has often been remarked that certain states of the weather and of temperature are particularly propitious to the operation of sowing. In the spring, when the atmosphere is loaded with fogs, which, particularly at sunrise and early in the morning, give to the boundaries of the horizon an apparently undulatory motion, so that the rising sun appears, in the language of the people, "to dance." When this is the case, large barley may be sown with peculiar advantage. Many agriculturists attribute great advantages to the seed being brought in contact with the dew, and, consequently, recommend that the sowing should be performed toward evening, and the seed not covered until the following morning; but this can only managed when the nights are warm. If there is any danger of white frost coming on, the seed must be covered at once.

Many agriculturists give it as their decided opinion that the seed should be got into the ground at the earliest period at which the operation can be performed, and as quickly as possible. But by acting up to this maxim in the fullest extent of its meaning, we shall run the risk of sustaining great loss, especially if we neglect those considerations which have reference to the state of the soil and the temperature. In all cases, however, everything should be kept in readiness to embrace the first favorable moment. The English have a saying, "You had better be out of temper than out of season." What is chiefly to be avoided is the neglecting a suitable amount of preparation, from a desire to sow early.

Formerly the moon was supposed greatly to influence the period of sowing; certain seeds were to be put into the earth during the moon's increase, others during its decrease. The rules appertaining to this theory had almost been forgotten, when a skillful and experienced American gardener revived them by relating his own experience and experiments, and he brought over several Englishmen to his opinion. A natural philosopher seeks to explain the influence of the moon, by saying that the uninterrupted action of light which takes place when the moon shines throughout the whole night may possibly be injurious to plants during their period of germination, since it is a well known fact that light is not favorable to plants which are in this state. It will be advisable to wait until this system is confirmed by a greater number of facts and experiments before we allow ourselves to be at all influenced by it.*

Each kind of seed ought only to have a covering of earth of such a depth as is suitable to its nature. So long as this depth is not exceeded, there is no doubt but that the seed will shoot the better for being placed at a considerable depth below the surface, because it there finds the necessary moisture, and the young shoots which are given off from its roots, run less risk of being parched, deprived of earth, or destroyed by frost. But too thick a covering might very possibly entirely prevent the germination, or, at any rate, present too great an obstacle to the putting forth of the seminal leaves. As a general principle it may be admitted that the larger the seed the thicker is the covering it can bear; while very fine seeds will only bear a light covering of earth.

There are three methods of covering up the seed in agricultural operations:

1. By sowing under furrows, and burying the seed by plowing.
2. By sowing upon furrows, and burying the seed with a harrow.
3. By sowing in land which has been plowed and harrowed, and burying the seed by a second harrowing, or by passing a roller over it.

And to these we may add a fourth, viz.:—

4. By burying the seed with a drill, or some machine of the kind.

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Of all the questions relating to this point, the most difficult to solve are those of the average depth at which to sow, the quantity of seed which ought to be put into the earth, and where the ground should be sown thickly and where scantily. As the expressions "to sow thickly" or "scantily" are absolutely relative, we must first of all determine what we mean by them; and this is not difficult, since we find a very great uniformity of opinion in almost all nations and climates respecting the quota of seed which ought to be sown on a given space.* The medium quantity is, if we reduce the land and the seed to our measure, between eighteen and twenty *metzen* of Berlin † per acre; this measure applies to every kind of grain but oats, which are usually sown one-quarter or one-half less thickly.‡

If there were any means of spreading the seed uniformly over the land, and each grain produced a plant, such a quantity of seed would be excessive. Count Podevil, in his account of his agricultural experiments, has calculated that where this quantity of seed is used, each square foot of ground receives ninety-one grains of rye; and states that on examining one of the thickest covered portions of the field, he has found only thirty-two plants growing. It appears to me impossible that even that number could attain to maturity, for there could not be sufficient room or nourishment for them on so small a space; at any rate they would put forth no suckers, nor would each plant produce more than one ear. I have often observed that in very fine corn crops, where the ears were large and full, although not sufficiently so to cause them to be laid, and which have yielded a produce far exceeding that which might be expected from the fruitfulness of the soil, there were not more than five or six plants on each square foot of ground; and, indeed, my general experience leads me to be of opinion that they cannot thrive if they are much thicker, for, wherever a greater number of plants spring up, the weaker ones disappear, and only the more vigorous arrive at maturity.

But as, in the ordinary process of sowing, it is impossible to ensure the seeds being uniformly dispersed, and can still less expect every plant to succeed, we cannot be at all guided by these statements, however true they may be; therefore the sowing should always be sufficiently thick to leave no spot scantily supplied with seed, and then either trust to Nature to thin the plants on those spots where they may be too thick, or clear it subsequently by hand. As experience has pretty generally determined the measure of seed, which, according to the ordinary manner of sowing, is the most suitable, and as those who have endeavored to reduce that quantity have generally been far from successful, so long as they persisted in adhering to that reduction, the agriculturist will do well to adhere to the old proportion.

But if the method of sowing can be sufficiently improved to enable us to calculate upon the seed being uniformly dispersed, and if the mode of burying the seed can be so contrived as to ensure each grain being placed exactly at a proper depth, the success of the crop may be thus rendered more certain; and if, at the same time, the richness of the soil leads us to entertain well grounded hopes that each plant will put forth several suckers, it is evident that at least half the seed may be saved.

The greater or lesser quantity of seed to be sown should therefore be determined—

1. By the skill of the sower, as upon this depends the uniformity and equality with which the seed will be dispersed over the surface of the soil.

2. By the goodness of the seed, or by its being such as leads us to believe that a very great majority of the grains will produce healthful plants likely to attain maturity.

3. By the temperature being favorable or unfavorable to the sowing; and by the state of the moisture of the atmosphere and soil being more or less advantageous to the kind of grain which is to be sown.

4. By the firmness or looseness of the soil, and the state in which it is at the time the seed is sown; and whether such a state is likely to be favorable or not to the process of germination, and the striking out of the roots of the plants.

5. By the fertility and richness of the soil, and its adaptation to the nature of the produce to be

* Here our excellent author is in error: such an uniformity does not exist. The quantity of seed which I have seen used, and have myself allowed for a given space on my lands in Italy, is but exactly the half of what is ordinarily used on the borders of the Lake of Geneva. [*French Trans.*

† A "metzen" is 100 English quarters.

‡ The portion of seed requisite for different crops and different soils, the advantages of changing the seed, and of varying the ordinary quantity employed, are all themes to which considerable and lengthened attention might be profitably devoted by the farmer. We have little doubt that on many soils the proportion of seed usually applied for the cereal grasses might be profitably diminished one-half. There is a very excellent pamphlet by Mr. Hewitt Davis, on "the advantages of diminishing the quantity of seed," which the farmer may consult with advantage. The following table gives the ordinary proportions employed in England: *(Johnson's Farmers' Encyclopedia)*.

	Time of sowing.	*Broadcast.*	*Drill.*	*Dibbler.*
Wheat	Sept. to Dec.	2½ to 3½ bushels.	2 to 3 bushels	1½ to 2 bushels
Oats	Feb. to April	4 to 6	3½ to 4½	2½ to 3
Barley	Feb. to May	3 to 4	2½ to 3½	
Rye	Aug. and Sept.	2½ to 3½	2 to 3	
Beans	Nov. to March	3 to 4	2½ to 3½	2 to 3
Peas	Jan. to March	3½ to 4½	3 to 4	3
Tares	Aug. to March	2½ to 3	2 to 2½	
Buckwheat	May	2 to 2½	2	
Clover, Red	March and April	12 to 16 lbs.	10 to 14 lbs.	
Clover, White (Mixed seeds.)	Ditto	3 to 4 lbs.		
Trefoil (Mixed seeds.)	Ditto	2 lbs.		
Red Clover (Mixed seeds.)	Ditto	2 lbs.		
Rye Grass (Mixed seeds.)	Ditto	1 peck		
Turnips	May to Aug	2 to 3 lbs.	1½ to 2 lbs.	
Mangel-wurzel	April and May			
Potatoes	March to June			20 to 25

sown in it; as this latter point may have considerable influence upon the development and success of the plants.

6. By the period at which the sowing takes place. Early sowings favor the growth of suckers, and this growth then takes place before the plants acquire stalks. This point is of so much importance that, in some kinds of grain, only half as much seed need be used when the sowing takes place in July, as would be required if that operation was performed in October.

By duly weighing all these considerations, a clever agriculturist will be enabled to determine whether to diminish or increase the amount of seed to be put into the ground, without troubling himself with any of those theories which advocate the seed being sown thickly on rich land, and scantily upon poor land, or *vice versâ*.

Among the greater number of those agriculturists who, in tilling their land, blindly follow one old routine, we find a greater inclination to augment than to diminish the quantity of seed. This proceeds partly from a prejudice in favor of the maxim which inculcates the doing of too much rather than too little; and partly from the fact that, in the early stages of their growth and vegetation, thickly sown plots have always a finer appearance than those which are thinly sown. I have always observed that persons are gratified by the sight of thickly covered fields, although it must have been evident that the greater number of plants must, of necessity, be stifled and perish, in order to leave room for the others to arrive at maturity. In their reciprocal struggle, the plants always weaken each other: and hence a period always arrives when those thickly covered fields assume a yellowish tint. If the weather be unfavorable, whole patches of vegetation perish, and vacant spots are left where there were previously the greatest number of young plants. I do not deny that the plants which perish afterward serve as manure to those which remain, but this is a very expensive kind of manure; and it not unfrequently, especially in autumnal sowings, causes a general putrefaction.

The principal motive usually assigned for sowing the seed very thickly is the necessity of stifling weeds; but I cannot say that I ever found it productive of this result. A plant which throws out numerous strong suckers, without, however, forming a compact tissue on the soil, compresses the weeds; but this is not the case with thickly sown plants. If the soil and the temperature are more favorable to the seeds of weeds contained in the soil and mixed with the grain than they are to the kind of grain which has been sown, the weeds shoot up as well as the corn, and often maintain their place better. The excessive thickness of the corn is in itself sufficient to prevent it from vegetating quickly. There is an example of this in the marshes of the Oder, where twice the usual quantity of oats is generally sown, often as much as three bushels *(scheffels)* of seed are allowed per acre, and yet the weeds are there as abundant as in any other place: they always dispute the ground, particularly with corn; and the temperature, according as it favors the one or the other, decides the mastery, unless these weeds are torn up by the hand, an operation which most small farmers undertake. I adhere firmly to my practice of sowing one-half as thickly as my neighbors, and can safely say that I do not suffer more from weeds than they do; nor have I ever yet found myself reduced to the necessity of laying down my arable land as pasturage on account of the weeds' having gained the ascendency. In fact, the ordinary quantity of seed is sufficient to cover the soil so completely that each spot will bear a more than adequate number of plants. The only kind of grain which I sow more thickly than any other is oats upon fallow or newly broken pasture ground, and that because then every grain does not fall on a place where it can germinate.

The processes of sowing vary infinitely, and it is scarcely possible to give a verbal description of them; but this operation, however performed, is always an important one. The best mode of proceeding is, doubtless, that which is termed the *broadcast sowing*, in which the sower throws the seed, as he goes up the field, to the left with his right hand, and as he returns to the right with his left hand, or else he walks on the edge of the furrow and casts it with the wind each time coming along the edge of that portion of land which was sown by his preceding cast; but this kind of sowing requires very great nicety and some skill on the part of the sower. But the wind must be well observed, and the extent of its power calculated. In all cases that mode of sowing is best in which the sower is most skilled, and there is always some risk in adopting a new one until the man has practiced it carefully.

It is a generally acknowledged fact that the sower is one of the most important of all the agricultural laborers; many agriculturists, however, attach little or no importance to the selection of him, and entrust this operation to any day-laborer or servant. They even go so far as to set him, as his day's task, a certain quantity of grain to sow; this the man likes well enough, for it is very easy for him to cast a great quantity of seed into the earth. In most farms an excessive quantity of seed is used compared with the extent of land sown, and it becomes necessary to sow thickly in order to make up for the badness of the sowing. If it be desired to fix upon some sort of rule for guidance, let the quantity of seed be based upon the extent of land to be sown; and, first of all, let a skillful sower be secured, and care taken that he shall not be too much hurried, but kept in a humor to do his work properly.

It has often been asked how much work a sower con do in a day: *De Munchausen* has calculated this in his first volume of "The Father of a Family." But we ought to be satisfied if a sower sows eighteen acres per day. This is undoubtedly the least that a man of ordinrry activity ought to get through, and I have met with many skillful sowers who will get through twice as much. But the action of sowing is very fatiguing; and a man who, by the uniform and equal manner in which he disperses the seed, saves a great deal, has some claim upon our consideration. If he be neglectful, he should be immediately discharged: it is in the utmost degree necessary that the skill of the sower should be ascertained, since on that depends the nature and extent of the preparation which must be made for covering the seed.

On very large farms two sowers often walk side by side, and act at once; but these men should be accustomed to act in unison, otherwise harm rather than good will result from the practice. For my own part, I prefer assigning to each sower his own separate space.

Still greater skill and more attention is requisite to sow fine seeds and spread them uniformly and in small quantities over the ground, than is in the sowing of grain; this operation ought only to be confined to persons who are conversant with it.

The difficulty which has been experienced in certain localities of finding good sowers, has rendered the drill plows or sowing machines particularly valuable. Several have been invented and recommended, but I cannot say that I have yet met with any machine of this kind which distributes the grain uniformly. Indeed, I have only seen the models, and have not witnessed the performance of the operation of sowing by one of these machines, or seen the crops sawn with it. Some drill-plows have been invented which only spread the seed, while there are others which both spread and cover it at the same time. The first of these may be useful, and is very simple; the others are complicated, not to be depended upon, and do not distribute the seed uniformly. I doubt whether any machine whatever can equal the sowing of a good sower; but I am willing to admit that its action may be far preferable to the performance of a bad one.

It is quite otherwise with drills or machines intended for the purpose of sowing in rows, for they deposit the seed at regular distances, and leave intervals of space between, which may either be hoed or stirred. Without them it is almost impossible to sow with any degree of regularity, nor can the plants be dispersed in a uniform manner; but, on the contrary, there will be an accumulation of seed in the furrow—which defects can only be counterbalanced by careful hoeing.

Hereafter, when I have described the manner of sowing different kinds of seed, I will speak of some of the most important points relative to cultivation in rows.

The period at which the seed shoots up and begins to show itself, depends partly upon its particular nature, and partly upon the nature of the soil and the state of the temperature. All plants present themselves either with a leaf, or in form of an awl, or with two seminal lobes. All gramineous plants rise from the ground in the first-mentioned manner: we will now proceed to treat in general terms of the sowing of that class of plants.

Taking the word in its strictest sense, we mean by the expression *corn*, plants bearing ears and belonging to the gramineous class, and which we cultivate for the sake of the nourishment contained in their seed or grain. It is true that many persons include under this denomination all the various kinds of plants which are cultivated for the purpose of procuring their seed, and employing it as an aliment; but, as those we designate corn are of a higher order, and resemble each other more than they do any other kind of plant, we shall apply this denomination solely to those which belong to the genus of gramineous plants properly so called.

It has not yet been ascertained in what place corn grows spontaneously, or, indeed, whether any countries exist in which such is the case; for nothing exists to prove that it has been anywhere met with growing wild. This circumstance, and the probability that it is very much changed from its primitive state, apply in common to it and to domestic animals, both of which have appeared in all climates where man has been, and have accommodated themselves to all the various changes and modes of human existence.

If we consider them in an economical point of view, they are distinguished from other gramineous plants by their seeds, which are larger than those of other plants, and full of flour, and it is this reason which induces us to cultivate them; the seeds of various other gramineous plants are equally nourishing, and of a similar nature, and are occasionally employed as food, as, for example, tares.

It appears that they were originally annuals in warmer climates. Some of them only have been habituated by cultivation to pass the winter in the earth, because our summer does not suffice to bring them to maturity.

They have, like almost all the gramineous tribe, a disposition to form tufts, and to multiply themselves by throwing off suckers and knots of new roots, which latter again produce new offsets, particularly when new earth has been piled round these shoots, and the growth of the stems stopped. By carefully preventing these latter from growing up, it is possible to preserve them for several years, and oblige them to form a thick turf.

They may be made to produce an enormous quantity of seed by thus encouraging their multiplication, making them throw off suckers, and then separating and replanting their offsets. It is thus that the Irishman, Millar, procured in one year 21,109 ears, and in these ears 576,840 grains of corn, from one grain which he planted in June, and from which, at different times during the following spring, he obtained offsets, which he planted; and be was of opinion that, if be had tried, he might still farther have increased this quantity. Several other persons have, with still less care, obtained from one single grain 40,000 grains in one year only; so that it is laughable to hear persons talking of the seed being multiplied 80 or 100 times, as if that were something extraordinary.

These gramineous plants always extend innumerable fibres from their roots to the superficies of the soil, and bind it together by the tissue thus formed; they likewise ramify considerably in the depth of the soil, wherever they find loose and rich earth.

All sorts of corn or grain contain constituent parts of a similar nature; but which vary in their proportions, and, in some sorts, in their combinations.

The first of these constituent parts is *gluten*. This substance was first of all discovered in wheat, and attributed to that kind of grain only; but it has since been found, although in a lesser quantity and more closely united with the starch, in other kinds of grain. This substance is intimately allied with animal matter; it is composed of the same primitive substances, and acts in the same manner when undergoing alteration, or submitted to the action of fire. Hence it forms the most essential aliment of the animal frame, and the nutritive properties of wheat depend, where there is an equal weight of flour, on the quantity of this substance which the grain contains. The proportion of it found even in the same kinds of grain varies greatly.

The second is *starch*. This substance is probably inferior to gluten in point of nutritive properties. Nevertheless, it is very nourishing, and appears to favor the digestion of gluten. Instinct

strongly inclines both men and animals to covet it as food; and, in the long run, it is preferred to gluten, which often tends to cause illness. Cattle fed in starch manufactories afford an excellent illustration of this.

The third is a sweet, *mucilaginous* substance, which is only to be found in small quantities in wheat; but which increases during germination, or in the preparation of malt, and is formed of starch. It is by means of this substance that the grain becomes adapted for acetous or vinous fermentation; it appears to be akin to starch in point of nutritive properties, and to assist in the digestion not only of gluten but also of starch itself.

In the natural state of the grain, these three constituent parts are only blended together. By the simple act of digestion, or by the process of making into bread, they become more intimately combined, and can then no longer be separated. In digestion a mass is formed similar to glue; but in the process of making bread, fermentation takes place which produces carbonic acid, and renders this aliment easier of digestion.

The fourth is the *husk*. This is composed essentially of fibrine, which cannot be dissolved by means of digestion alone; however, it contains a somewhat soluble and aromatic matter.

The fifth is *moisture*. This is to be found even in the driest grain; it increases the weight and bulk of the grain, although it diminishes its specific gravity. It yields no nourishment, and is of no advantage; but, on the contrary, when existing in too large a proportion, it accelerates the deterioration of the grain, for which reason grain should always be kept dry. The artificial modes of drying grain, which are practiced in the northern countries on the borders of the Baltic, by means of drying-floors or planks, tend to preserve the grain much longer, especially if it be placed in large heaps, by which means it absorbs less of the humidity of the atmosphere. Grain which has not been dried in any way ought, on the contrary, to be exposed in thin layers, so that it may be generally exposed to the air; it should be frequently stirred or otherwise moved about, in order that the moisture which it contains, as well as that portion which it attracts from the atmosphere, may evaporate. Different observations and experiments tend to give rise to the belief that by means of an absolute seclusion from contact with atmospheric air, grain may be prevented from deteriorating; but this cannot be, unless it has first been thoroughly dried.* These constituent parts vary in their proportions not only in the different varieties of grain, but also in the same kind. The temperature of the season, the kind of manure bestowed on the soil, the maturity of the crop, and the period at which the harvest takes place, all conspire to influence the relative proportions of these matters. Corn which has grown on a humid soil, and in a moist temperature, has a very thick husk, and, consequently, is not so heavy as that grown under opposite circumstances, although apparently the same in volume. The proportions of the other constituent parts vary in a like manner. Hence it happens that we often find grain grown in one year so much more nourishing than that of others.

The nutritive properties of grain are not always in exact proportion with its weight; the ratio is, however, very approximative, and much more so than that of the nutritive properties with the volume; consequently, it will always be advisable to buy, estimate, and employ it according to its weight rather than its measure. This is now generally admitted with reference to the manufacture of brandy from grain: skillful and experienced distillers are always guided by weight rather than measure.

The weights of the different kinds of grain vary; a bushel of grain, Berlin measure, will weigh as follows:—

Wheat	from 84 to	96 lbs.	Small Barley	from 55 to	70 lbs.
Rye	76	86	Siberian Barley	74	86
Sprat, or Battledore Barley	65	84	Oats	42	56

The produce of different kinds of grain depends, where the temperature is equal, on the fruitfulness of the soil; and these kinds of produce exhaust the soil in proportion to the luxuriance of the crop, the size of the grain, and the quantity of nutritive matter which it contains. For their vegetation and increase depend in a great measure, if not entirely, on the nutritive matter suitable to it contained in the soil, but the proportion of these required has not yet been determined.

Some persons have endeavored to determine the sum total of the produce of each kind of grain throughout entire provinces and countries: but the data whence these conclusions were deduced were far too vague to be depended upon, and, consequently, no reliance can be placed on them; much less can they be applied to particular cases, and to certain modes of cultivation. Thus, when we take the average of several years, we find that our calculations are sometimes above and sometimes below the results above named.

In Northern Germany, the average is usually taken from the triennial rotation with a fallow.

Of Wheat	7 bushels.	Of Barley	6 bushels.
Rye	6	Oats	5

according to the order in which these crops follow the last amelioration.

In countries where a great part of the land is badly cultivated and carelessly sown, this average must be taken at a lower rate; only five bushels per acre must be allowed. *Schwerz*, according to his notes, which, however, cannot, in my opinion, warrant such a deduction, states that the average in Belgium, per acre, Magdebourg measure—

Is in Wheat	11·80	bushels Berlin measure.	In Autumnal Barley	17·95	bush. Berlin meas.
Rye	12·28	do.	Oats	24·76	do.

He contrasts with this several of the statements of Arthur Young, in his travels through the

* On the borders of the Adriatic, and in situations where the influence of the atmosphere and of insects are very prejudicial to grain, I have seen wheat preserved in walled pits formed in the earth, having but one orifice, and that one hermetically sealed. A long stick is inserted into this pit, which reaches to the bottom; and this is from time to time drawn out to show the state of the temperature of the grain in the interior of the pit. If it indicates heat, the grain is immediately taken out to give it air. [*French Trans.*

north, south and east of England, and calculates the general average of the produce in England at that period, viz. from 1760 to 1770, at per acre, Magdebourg measure—

Of Wheat	9·39 bushels, Berlin measure.	Of Spring Barley,	12·60 bush. Berlin measure.
Rye	9·58 do.	Oats	14·38 do.

Hence he infers the Agriculture of Belgium to be superior to that of England. Taking this latter as a whole, nobody will deny the truth of his inference, not even the English themselves; but, if he here includes this rotation, which was formerly only practiced in some small districts of England, and which has not until lately been generally adopted, or if he means to infer that this rotation is not so good as any other, not only does he draw a false conclusion, but he shows that he has not read Young with attention, and that he has not comprehended the end at which he aimed, which goes directly to prove that the ordinary agricultural undertakings in the provinces through which he has passed are still very imperfect, and that they might and ought to be improved by a better system of tillage. If he had exhibited the average produce of improved farms which Arthur Young gives, particularly in those travels which were made at a later epoch, when there had been several established, the result would have been nearly as follows:

For Wheat.............	15 bushels per acre.	For Oats................	24 bushels per acre.
For Barley..............................	18 bushels per acre.		

In those provinces they do not cultivate rye, at least to any extent.

I have before spoken of the proportional value that one kind of grain bears to another.

During the period of the vegetation of cereals, great attention must be paid to those circumstances and accidents which we are about to notice, and to the making of those preparations which we shall point out.

So far as regards autumnal corn, it is considered advantageous for the plants not to shoot much at first; but, on the contrary, for the grain to lie in the earth for a period proportionate to the temperature which they contain, because then the inferior part of their germ, the root, becomes more developed and gains strength. I have remarked, where the weather is favorable and the soil deep, the seeds spring up just three days later than they do in a shallow soil. When an extraordinary state of dryness in the soil causes the seeds to germinate very slowly, we cannot regard this as advantageous; however, it is only injurious on account of its retarding the vegetation too long. In the autumn of 1810, the rye sown toward the end of August remained in the ground until nearly the end of October, that is to say, seven or eight weeks, and many persons thought that it would never spring at all. It did, however, eventually shoot above the ground, and came up tolerably thick, and would have yielded a good crop of grain if the drouth had been less excessive in the spring, and it had been able to throw off suckers as usual. With respect to spring corn, it is desirable, on the contrary, that it should come up promptly, in order that the weeds may not gain the ascendency.

It is a good sign when corn comes up in a uniform manner, whether we consider it with relation to time or strength. If it comes up slowly, and be unequal in strength and color, that announces some disease. It is more deplorable to see spring corn shoot up twice than autumnal corn, because the latter acquires a uniform appearance more easily in the spring, whereas the other retains the disparity.

The germ which first appears ought to be of a deep color: if rye, a brown verging on red; if wheat, rather brown; if spring corn, of a deep green; but in no case should it be tinged with yellow: this latter hue denotes a disposition to disease, from which the plants seldom recover. The first leaves which develop themselves should be short, thick, and somewhat obtuse at their points, tough, elastic, and given to curl and contract themselves.

After the development of the first leaves, the stalk forms a knot above the root; this knot opens, and from all sides of it come out lateral shoots. The more perfectly this takes place, the more vigorous may we expect the corn to be. These shoots must not grow too speedily, still less should they fall or fade on account of weakness; on the contrary, it is desirable that they should rise tough and elastic above the soil. In autumnal corn I have frequently seen offsets shooting up vigorously, acquiring a great hight, and bearing leaves of a light green hue, succeed to an amelioration of the soil in which manure had been buried a short time before the sowing, during moist, warm weather: this activity of vegetation was attended with the most deplorable results, and all that remained in the spring was a field almost entirely despoiled of vegetation. It appears that in such a case the amount of hydrogen contained in the plants was out of all proportion to the carbon which they contained. Under such circumstances as these, it does not appear to me that there can ever be any disadvantage in the soil being richly furnished with plants, even though the leaves were to rot the plant; for the plant, protected by its lateral offsets, would remain healthful, and in the spring would resume its vegetation.

The commencement of winter finds autumnal sowings in various conditions: some of the kinds of grain have not germinated, when others have begun to shoot. In whatever state they may be, I have never yet seen them destroyed by frost. During the extreme cold weather of the rigorous winter of 1802 and 1803 the earth was free from snow, yet I could not perceive that any plant had been destroyed; I had not, however, any opportunity of seeing white wheat. In the following spring all the sowings looked wretchedly; those which had thrown off suckers before the commencement of winter had lost their leaves, which at first turned of a whitish hue, then half rotted, and at length dropped upon the soil: no new shoots were perceptible. It was not until the end of April that the rye began to put forth new shoots; the wheat did not recover itself until the end of May. Up to that time the frost, which had penetrated the soil to the depth of more than three feet, absorbed the whole of the caloric brought into contact with the soil by the atmosphere. Subsequently the plants shot up again with promptness and vigor: no blanks were to be perceived, excepting in those places where the soil had cracked to such an extent as to render it dangerous to approach it; and even these places were subsequently covered to a tolerable

extent after being closed up by the expansion of the earth. The rye alone, which had been sown on shelving beds of sand, wherein it had thrown off no suckers before the commencement of winter, was found to be destroyed, a strong easterly wind having swept away the sand, and left the roots bare.

The seed is, undoubtedly, best preserved under a bed of snow, particularly when the superficies of the soil is somewhat hardened before the snow falls. It continues to grow beneath this covering, and the seed which has been buried for but a short time shoots out and springs up beneath the shelter of the snow. However cold the weather may be, and however long it may last, the seed thus covered does not suffer at all from it; indeed, the coldest winters have always been followed by the most abundant harvests of autumnal corn. Mild winters, with frequent alternations of heat and cold, are invariably injurious to all seeds sown in a moist soil, unless good and sufficient measures are taken to keep the soil well drained. Neither should the snow be trodden or pressed down upon the seeds; wherever footpaths, or even footprints, have been made in deep snow, the greater part of the plants underneath disappear.

When the snow and frost are disappearing is a very dangerous period, if not the most dangerous of all. The seed is liable to be drowned if the snow happens to be precipitately melted by rain, and the water be so enclosed that it cannot flow off, or the ditches so full of frozen snow that it is impossible to open their channels. In such cases, nothing but extreme promptitude and activity on the part of the farmer can save the seed; he must employ all the hands he can muster in endeavoring to procure a drainage; and, after all, he will sometimes strive in vain, it being impossible. On a soil through which the water filters freely, some hope may be entertained that it will sink into the earth before the plants perish; but such can never be the case when the frost has taken deep hold of the soil. A thaw is still more injurious to the seed when it comes on very slowly, and is accompanied by alternations of frost. When there is sunshine during the day, and frost during the night, or, what is still worse, when there happens a fall of snow during the night, which is soon melted by the sun, the thawed superficies of the soil becomes saturated with water, which is unable to penetrate through the inferior stratum, and still continues to be hardened by the frost; this water freezes during the night, and, in doing so, raises up the superficial layer of earth subjected to its influence, and with it the plants growing there. During the day the earth thaws again, and the earth falls back to its original position; but the plants, being lighter, remain on the surface, wholly denuded of earth. For several successive nights and days, the same thing is frequently repeated, and by far the greater number of the plants are thus uprooted—even the roots themselves being broken where their lower extremities have been tightly fixed in the frost-bound earth. Even the most vigorous plants cannot entirely resist such weather; those, however, which have most roots and are most tufted, bear it better than others. The more porous the soil, the greater is the danger.

Such weather as that of which we have just spoken occurred in March, 1804; and it was the sole cause of the partial failure of the corn crops, and the dearth of grain which was felt that year, which was, nevertheless, otherwise favorable to vegetation.

In the spring, if the seeds do not come up well, or the plants appear to be rather thin, people are apt to become alarmed lest they should have been entirely destroyed during the winter, or else have suffered too much to admit of the hope that they will yield even a passable harvest, and often hastily determine on plowing the land up. There is no year that I can remember in which the farmers were so uneasy, and so much in doubt as to what they should do, as in 1803. However, the greater number of those who plowed up their autumnal corn, in order to sow spring barley, regretted it afterward; because the autumnal sowings which were allowed to remain yielded a far better crop than the barley by which the plowed up portions were replaced. Indeed, a satisfactory crop of barley is rarely obtained under such circumstances; oats will, in general, be found to answer better.

Sometimes agriculturists have carefully harrowed autumnal wheat which appeared to be quite destroyed, and then sown oats on the ground; they have subsequently reaped oats and wheat together, and, upon the whole, had a good harvest, but the wheat has exceeded the oats in quantity.

The experiments made on this point by some of the Mecklenberg agriculturists, and which are narrated in the second part of the "Annals of the Agricultural Society of Mecklenberg," are both interesting and remarkable.*

It has also been found that, by passing a harrow carefully over the ground in spring, when the soil is thoroughly dry, very beneficial effects have often been produced, even when the laborers have expressed their fears that the operation would absolutely destroy all that remained of the wheat plants. Harrowing is, without doubt, one of the most beneficial operations which can be applied to autumnal corn; but it must be sufficiently effective to cover the whole field with a layer of loose earth, as will always be the case when harrows having iron teeth are made use of. Recourse may be had to this operation with advantage in every case, excepting, as we have already said, where the plants have been uprooted, when it will be better to roll the ground. A mild, dry March is particularly favorable to the vegetation of autumnal corn, as well as to the preparations for putting in spring corn.

In the spring, all corn which looks well and healthy ought to put forth lateral shoots, extend itself over the soil, and gain strength, rather than run up rapidly. The vigorous nature of a plant which has already begun to show offsets in the autumn, contributes greatly to further this end; but the weather must be favorable, the heat in April and the beginning of May very moderate, and a sufficient quantity of rain must have fallen to moisten the ground and render it favorable to the vegetation of thickly tufted corn. Then the operation of harrowing will prove particularly beneficial, especially if performed in a proper manner and at a fitting period; the layer of newly loosened earth encouraging the plants to sprout and put forth new shoots. Should they, however, after this, shoot up rapidly, with only one or two stems, and run to stalk—as very frequently happens when there is a sudden rise of temperature unaccompanied by rain—the corn never becomes

* See the "Annalen des Ackerbaues."

thick; and even though lateral shoots subsequently appear, which are called "May-shoots," they being so much later than the principal stems, never produce any ears of much value. It is not so much the crowding together of the plants, as this multiplication and elongation of the offsets—this uniform sprouting of new stems—which decides the question as to the richness of the harvest; and in that the appearances change almost incessantly. One field, which at the commencement of May is covered with plants, and makes a very great show, will in June be but scantily furnished with ears, the plants having run up to a great hight and become stalky; while another, which appeared to be very much behindhand in May, will in June present the aspect of a field of thickly tufted corn, luxuriantly furnished with ears and thick stems. Most agriculturists will have had opportunities of observing this phenomenon, but only a very few of them have profited by this experience; since they mostly like to see their fields covered with straight, thick plants in the autumn and early in the spring, without caring to consider whether these crops bear any indications of strength or are likely to shoot out luxuriantly. The aspect presented by a field of corn, cursorily examined, is very deceitful. It is only by going over the field and examining all the plants separately, that any definite opinion can be formed with respect to its fruitfulness.

The slower the growth of the stems and the development of the ears, the better. A forward, precocious crop will never be a luxuriant and plentiful one. The ears should be uniformly developed over the whole field about the same time; and for this reason cool, damp weather in May is considered to be favorable to the production of a plenteous harvest. At the time when the ear begins to form, the plant will have attained the half of its ultimate hight; at least, I have always found this to be the case as regards rye. The strength of the stems, particularly toward the bottom, is of quite as much importance as their hight. It is only when the stems are proportionately strong that the length of the ears will be in proportion to that of the straw; as, for instance, the ear will be nearly as many inches long as the entire stem is feet in hight. Thin, wiry stems often attain to a considerable hight, and, nevertheless, bear small ears. The knots of the stem ought to be thick and brown; the blades of a deep rich green, and stiff. When the ears have acquired an increase of growth, and the flowering begins, the corn ought to present a uniform surface, and all the plants be the same hight. When some ears here and there shoot up higher than any of the others, it does not presage a good harvest.

The flowering season is also a critical period for corn. If the temperature continue to be wet for any length of time, fecundation will be difficult and imperfect. In June, a dry and warm temperature, with a few intervening showers, is desirable. As the weather exercises a considerable influence, especially on rye, I shall take occasion to revert to this subject again. It is astonishing how much greater a resistance vigorous corn opposes to the action of weather, &c. than that which is offered by the weaker kinds.

During and after the period of flowering, comes the danger of the plants being laid. When corn is laid previously to this, without being beaten down by heavy showers or hail, it is in consequence of the excessive richness of the soil—a circumstance which every sensible and prudent agriculturist should always take care to avoid. Corn which has been beaten down previously to the flowering period soon rises again, but not without retaining a slight curvature.

When the corn is laid by rain, this evil is so much the greater in proportion as it takes place at an early period. It is not always the crowded condition of the stems, or their multiplicity, which causes the corn to be laid, but usually the weakness of the plants and their disposition to disease; for we often see corn that is very thin and scanty in one field laid, while that in an adjoining field, although thick and luxuriant, will remain erect. Very abundant manuring, with superficial and badly executed plowing, accompanied by very thick sowing, constitute the ordinary causes of the laying of corn; while deep plowing, performed with care, and seeds well furnished with offshoots, rather than thickly sown in the first instance, prevent this inconvenience. In the latter case, the stem has more strength at the lower part; and in the former it rises too rapidly, and obtains hight, and perhaps strength of blade, at the expense of the stem. All corn which is of a yellow color indicates the presence of too much hydrogen in proportion to the carbon, and consequent weakness.

What I have just said has reference principally to autumnal corn: however, in most points, it may be applied to spring crops as well. The peculiarities of each will be noticed when we come to treat of the several species separately.

Among the different diseases which, under various forms, attack corn, as well as other plants, during the period of their vegetation, the following are the most common and remarkable:

Abortion; or, the shedding or falling of the grain.—This disease causes the plants to become suddenly white or yellow, as if at the period of their maturity, and are soon completely dried up.

It is partly the top of the plant or the top of the ear that is first diseased; and this appears sometimes to be occasioned by the return of cold, or white frost. Grounds exposed to the north wind, and the highest parts of fields, are most subject to this disease; but it is often seen in wet land, and still more often in fields surrounded by woods, where frosty vapors fall in great abundance, which have a fatal influence on the young ears by suddenly chilling them.

Upon dry soils which contain great heat, and where the want of rain is experienced, we see another disease of a similar kind, but which attacks the whole plant: this disease is not confined to sandy soils, but manifests itself in fields which have been only superficially plowed, which are never left in repose, and which are abundantly manured with new manure a short time before the seed is put into the ground. I know extensive arable lands on which this disease always attacks the rye during dry weather, and the owners of the land believe it to be inevitable. Allowing the land to remain fallow, laying it down to pasture, plowing it deeply, or spreading the manure over the surface after the seed is got into the ground, will be sure to eradicate the evil.*

A disease called by the English *blight*, and which is of a totally different character to the one of which we have now been speaking, is seldom met with among us; it only manifests itself now and then, and usually appears in wet localities. It consists in a sudden paralysis of the vital

* *Vide* "Wirlich uber das Verscheinen der Saaten." Niedersachs: Annalen. Jahr. iv. st. iii. 54. A.

strength, a mortal apoplexy, a sudden death which attacks the plant. I observed this disease to be prevalent during the rainy but warm summer of 1802; it showed itself in patches in moist situations: one day an extent of some feet would lose color; on the next this appearance would have extended over the crop to a distance of thirty or forty perches. The plants became completely white, and as dry as straw. It was easy to pull them up, and all their principal roots came up with them quite white and dry: nothing remained in the soil but a few fibres. During that summer, the disease of which we are now speaking was far more prevalent on the fields in my neighborhood than upon my own; some persons attributed it to the ravages of an insect, but I was never able to discover a foundation for such an opinion, nor could I discover that the plants had received any injury which could account for their rapid decay. This evil appeared to me to be attributable to an electrical state of the air, or to an instantaneous mutation of positive and negative electricity between the currents of air and the earth, which were signalized by various indications, though no storm manifested itself in the neighborhood. It has long been considered that lightning has a baneful effect upon every kind of cereals, particularly if it comes about the time of flowering.

Mil or mel-dew brand, and smut, appear to me to be analogous the one to the other, or, at least, to have one common origin. Some agriculturists comprise, under the term brand, both the mildew and smut; and, in fact, the latter appears to me always to be a consequence of the former.— The *mil* or *mel-dew*, or, as it is vulgarly called, the *honey-dew*, is a glutinous, sweet humidity, which exudes from the plants, and is similar to honey: it is very agreeable to bees. Nobody will believe, in our days, that it falls from heaven, since it often attacks one whole crop of corn, while that which is perhaps in the very next field is free from it; the primary cause of it doubtless lies in the atmosphere; the disease is most prevalent when, in the middle of summer, and while the plants are in full vigor, during or after the flowering season, sudden changes take place in the air, and heat is succeeded by instantaneous cold: in fact, it is a disease produced by chills. Upon some vegetables, as French beans, there are immediately seen a quantity of animalculæ, which are undoubtedly the consequence, and not the cause of the disease. Among cereals, a small red insect may occasionally, but not often, be remarked: throughout the whole of the plant signs of weakness are observable, and its vegetation is checked. Should a more favorable temperature, however, supervene, accompanied by gentle showers, the plants will often be restored; yellow spots will continue to be visible upon the leaves and stem, which gradually acquire a deeper hue, and at length burst, shedding a brown powder; this is what is properly called *smut*, and I have almost invariably seen it succeeding to *mildew*. Botanists have for a long time considered these balls or spots to be little fungi, which grow on the leaves; and Sir Joseph Banks, the President of the Royal Society of England, in a recent description of this disease, which made such terrible ravages in England, particularly in 1804, has given a very magnified and detailed drawing of it, in which the form of the fungus is very clearly to be traced. Many botanists consider it to be a parasitical plant appertaining to the class cereals, and term it *æcidum*. For my own part, I am much more inclined to regard it as a disease of the skin; for plants, as well as animals, are subject to such, and each has a certain form. If this disease once gets a head, the plant soon becomes so weak that it is incapable of bearing grain, and all hopes of a fine and plentiful crop vanish. This disease is more frequent in some climates and countries than in others; and it is peculiar to those which are much subject to fogs. One very extraordinary fact is that the barberry bush will produce smut, or something very similar to it, in all corn growing within a considerable distance of it. This is a fact which has been confirmed by numerous observations and experiments in almost all countries. But it has never yet been clearly and satisfactorily ascertained in what manner the barberry produces this effect. My friend Einhoff has made several experiments on the possibility of communicating *æcidum* to cereals by cutting branches from the barberry, which were quite covered with it, and shaking them over the corn, or else planting them in the midst of it; but he never succeeded in thus producing the disease: therefore, it would seem that it is not the communication of this dust, but the vegetation of the barberry in the vicinity of the corn-field, which engenders the disease. Nor will it attack crops planted near young and newly made barberry hedges; but as these latter grow up the disease will appear, and increase in virulence from year to year, until these hedges are rooted up. As soon as the barberry has been thoroughly extirpated, the evil disappears.

The *farinaceous smut* is a disease in which the plants are covered with a white, powdery-looking substance. It seldom attacks cereals, but is usually found among vegetables. It appears to arise from the same cause as honey-dew, with which it is frequently confounded. It attacks those vegetables which are liable to it about the period of their attaining to maturity; and it is this age, and not the influence of the season, which predisposes the plants to it.

No definite information has yet been obtained with regard to the nature of the diseases of plants. Agriculturists seldom have the capacity or the leisure to admit of their observing and tracing out all the phenomena attendant on them; and botanists and other scientific men rarely have the necessary opportunities of pursuing this study. One opinion after another is brought forward, each founded on different views, and expressed in different terms; and hence endless confusion arises. As I have no intention of venturing upon such dangerous and untenable ground, I shall abstain from entering upon the subject of the analogy which is supposed to exist between the diseases of plants and those of animals. I shall also pass over in silence the various insects which occasionally do so much mischief to corn and other crops.

THE HARVEST.

The getting in of corn and other kinds of cereals is in general one of the most important of all the agricultural operations. We shall at once proceed to speak of the principal circumstances relating to it, without entering into those minor details with which the reader is most probably acquainted; or, if he should not be, which cannot be taught by verbal explanation. The principal conditions requisite to ensure the success of the harvest are, that it shall be got in as quickly as pos-

sible; that the plants shall not be allowed to shed their grain; and that the ears shall be firm, dry, and fully matured.

In order to avoid all impediments to the progress of the harvest when once it is commenced, the farmer should make every preparation beforehand; he should air and repair all his barns; see that his wagons, implements, and every thing which can by possibility be required are fit for use. Everything, in fact, should be got into a state of readiness, so that not a moment shall be lost after the operation is once commenced; all other operations which will not positively suffer from delay should be postponed. The straw bands, or twists of reeds or osier, with which the sheaves are to be tied up, should also be prepared beforehand, for no prudent farmer will suffer his sheaves to be fastened up with their own straw.

In extensive agricultural undertakings which have but few or no statute laborers, the first care should be to procure a sufficient number of hands; a calculation should be made as to the number which will be requisite, and every possible means resorted to in order to secure them. The usual mode of proceeding is to let off land to laborers, on which they are permitted to cultivate certain things—as, for example, potatoes, linseed, tobacco, &c.—on condition of their helping to get in the harvest at certain wages, or, if they fail to do so, forfeiting the produce of the land which they have cultivated. This mode of proceeding is, in general, very expensive, but it is often the only means of attaining the desired end.

There are various data laid down for determining the number of laborers which will be requisite to get in the harvest from a given extent of ground, but most of them have only relation to certain localities. By some it has been supposed that six men and eight women are required for three hundred acres of land, two-fifths of which are sown with autumnal, and three-fifths with spring corn. In this calculation, one man has been supposed capable of cutting three acres per day of fine corn, and from three to five women of raking and binding the corn. The quantity of corn which a team can draw in the course of the day will depend upon the weight of the crop, and the distance of the field from the stack-yard. One man and one woman will be sufficient to load and rake up after a wagon, and three men and three women will suffice to unload the wagon and stack the corn. This calculation is, however, liable to modifications—some laborers being more active than others, some more skillful. The number of persons required will also be greatly influenced by the state of the weather, which often tends materially to prolong or retard the operation.

There are various modes of performing the operation of getting in the harvest; it is, however, very difficult to change from one to another where the laborers cannot be hired from other places, and the farmer is forced to manage with those belonging to the immediate neighborhood. It is by no means immaterial in which mode the harvest is got in; some being advantageous in one point of view, and some in another. But the various isolated departments, viz. mowing, reaping, raking, binding, loading, unloading, and stacking, are all so intimately connected with each other that no change can be made in one which does not pervade the whole series. Any projected alteration must never be adopted without due consideration, since the laborers frequently go very clumsily to work about it, even though it may be much easier than the mode of proceeding to which they have been accustomed; innovations, too, often damp, if not destroy, that alacrity and cheerfulness on the part of the men which cannot be too diligently fostered during harvest time. Most reapers keep themselves and each other in good humor by intermingling jokes and pleasantry with the progress of their work; but these vanish before the imposition of a new mode of proceeding, and give place to sullenness and discontent; although the probability is that, in those places where it is customary, this very mode of operating may be even more merrily performed than that which these men are habituated to. If, notwithstanding this disadvantage, it should still be deemed expedient to introduce some new plans, care must be taken that all the chief laborers shall thoroughly understand it, and that the overseer, especially, shall be intimately acquainted with all its details, and fully capable of giving both directions and instructions with regard to it.

We shall not attempt to describe all the various modes of getting in the harvest, because it is difficult to give a sufficiently lucid description of these proceedings to be of any utility, although they may easily be acquired by observation and practice, but content ourselves with making mention of the principal ones.

The instruments employed in cutting are the sickle and the scythe. When the former is used, the corn is said to be reaped; and when the latter, it is said to be mown. The sickle or reaphook is to be preferred, when the reapers use it properly, as the ears are then less liable to shed their grain. The chief cause of the preference given to the scythe, is the saving of manual labor which it produces, and the despatch with which the operation progresses when this instrument is used. No doubt can be entertained but that, when the crops are thick, half laid, and interlaced with each other, the sickle should be used; and the advantage arising from the grain not being shed, will amply cover the extra expense attendant on reaping. But where any of the kinds of grain are allowed to stand too long, merely from a predilection for the use of the sickle, this advantage is entirely lost, and the quantity of grain which is shed and lost during the getting in of the harvest is often much greater than would have been wasted had the crop been properly mowed. It must not be forgotten that when grain is reaped, a very high stubble is left standing, and consequently the amount of straw is decreased. This, however, can hardly be termed a loss on strong, heavy land, where an abundance of straw can always be obtained, and where this long stubble will, if buried by plowing, tend to loosen and ameliorate the soil.

There are two ways of mowing corn: firstly, by means of a scythe surmounted by a *cradle*, which is made to cut from right to left, and which lays down the corn in swaths on the left; and secondly, by means of a common scythe, in which case the mower cuts toward the standing corn, on which the cut corn consequently rests. This man must be followed by an assistant, whose business it is to gather up the mown corn, and lay it on bands ready to be tied up. This second mode of proceeding can only be resorted to where the corn is strong and heavy. One great advantage attendant upon it is, that it shakes the ears much less, and saves the trouble of raking.

corn thus cut is less liable to shed its grain. The labor attendant on it is scarcely greater than would attach to other modes of proceeding, for the women who follow the reaper and gather up the corn save the extra labor of raking.

Many attempts have been made, and not entirely without success, to invent instruments for the purpose of performing the various operations appertaining to the getting in of corn; but the labor was so little diminished by any of them, and the corn in general so much injured, that no advantage whatever can be derived from their use.

The crops are sometimes tied up directly they are mown, while at others they are left in swaths or heaps on the ground to dry. The former mode of proceeding can only be resorted to when there is but little grass intermingled with the crop. Some farmers prefer leaving the grain in heaps on the ground until a little rain has fallen. When such is the intention, the sheaves must be made very small, or else they will take too long drying; the best way is to put the corn into sheaves standing, as it suffers much less from moisture while in that position than it does when lying on the ground. Under those circumstances, where the crops must necessarily remain for a considerable time in the field, as will often be the case where a tithe or duty has to be paid on it, the sheaves are placed together in shocks, and a cap or covering, consisting of a head sheaf, spread out for the purpose, which prevents the shock from suffering even from continuous rain. When the corn is made into large sheaves, they should be removed from the field as soon as tied up, and on no account suffered to remain another night exposed to the weather.

Nothing can be so disadvantageous to the farmer as for the weather to be moist and damp at the harvest time, as this state of temperature gives the grain a tendency to germinate. Under such circumstances, he will have need of all his forethought and activity, and must spare neither care nor expense if he would save his crop. He must, above all, preserve his good humor and cheerfulness, for any diminution of either will paralyze all, and cause the laborers, who otherwise take a lively interest in the operation, to become disheartened and sullen. Various modes of proceeding have been recommended for the purpose of preserving corn during harvest from the effects of warm, moist weather; but most of them are only applicable to some few localities.

When the corn is left in heaps or swaths on the ground, they must be frequently opened, and turned, in order that the ears may not become attached to the ground, but may be exposed to the action of a free current of air. Whenever there is the slightest chance of the corn drying, it should be immediately tied up, and carted with the least possible delay.

Sometimes it will be found necessary to turn the crop repeatedly after it has been brought into the barns, and to expose it to the action of the air by spreading it over the floor. The corn can only be tied up as fast as it is mown, in the middle of the day, and even then it will be best to set the sheaves in shocks, and cover the top with a head sheaf, or sheaf laid upon its side, and so arranged as to protect the shock from rain; corn may thus be suffered to remain on the field until the weather improves, without any danger of its germinating. Some farmers pile the corn in heaps without tying it, and then cover each heap with a sheaf drawn loosely together at the top, and stretched out at the bottom so as to form a cap. When. on account of the unskillfulness of the laborers, it is impossible to cover the heap properly, the sheaves must be made very small, each one weighing not more than eight or ten pounds, and these must be set up leaning against each other, so that the wind may blow through them. When thus exposed to the air, the corn can bear continuous rains for a considerable length of time.*

With us, the corn is usually preserved in barns until wanted to be threshed; and it is only made into stacks when the barns are too full hold more. There is a very great difference between our stacks, which frequently occasion so much loss to the farmer, and the carefully, systematically built corn stacks of the English agriculturist, such as I have described in vol. ii. part 1, of my "English Agriculture." These latter are fully capable of preserving all kinds of corn, without its being in the slightest degree injured or deteriorated; it would, however, be difficult to introduce them into our system, and, in fact, it could not be done unless the sheaves were very small. A building has been suggested which partakes of the nature both of a barn and a stack, and this is, in my opinion, very likely to answer. There are various opinions respecting the form in which barns or granaries should be built, and also with respect to the superiority of different barn floors. When these latter are long, a whole line of wagons may be introduced at once; but where they are square, not more than three at most can enter. In my opinion, the old custom, whatever that may be, should be adhered to; the advantage attendant upon either of these forms is not so great as to make it worth while to change the mode of getting in the harvest, and alter the construction of the barns. Long floors are chiefly found in those localities where the corn is not laid up compactly until the whole of it is tied; while square ones are principally found where the crop is carted and carried home as soon as any portion of it is made up into sheaves.

When corn is stowed up in barns or in stacks, it is of the utmost importance that no hollows or vacant spaces should be left, but that the whole mass should be compactly pressed together. This point should be particularly attended to, not only because much room is thus saved, but also because the grain then keeps much better. No practice can be more erroneous than that of leaving openings and vacuities with the view of admitting a free current of air, and thereby carrying off the vapors engendered among the cereals; it will always be found that corn keeps best when most compactly stored, and that wherever hollows or spaces are left, mildew will always be engendered.

There are various modes of threshing corn. I shall merely mention those which are effected by the feet of horses, by wagons having ten or twelve angular wheels, and by sledges, or conical rollers.† The usual way of threshing corn is with flails. These implements are not, however,

* Some remarks on this subject will be found in the "Annalen des Ackerbaues," bd. iv. sec. 82, and "Anzeigen der Leipsicher Œconomischen Societæt." Michaelis Messe. 1785. Sec. 50. "Untrugliche Weise bei regnigter Witterung, die Feldfrüchte in Sicherheit zu bringen." Weimar, 1810.

† A complete description of all these methods, which are now obsolete among us, will be found in "Krunitz Encyclopedia," bd. ix. illustrated by several plates.

always similar, nor are they always used in the same way, but none of the modifications, either in their make or in the manner of using them, are of sufficient importance to render it worth while to take the trouble of endeavoring to teach the laborers to perform the operation in any way to which they are unaccustomed, especially when they are upon task work.

Threshing is generally executed in one of three ways:

(*a*). In small farms: by the farm servants, either early in the morning or late in the evening.

(*b*). By day work: in this case the number of sheaves which are to be threshed in each day is usually determined beforehand. Where this system is pursued, the laborers must be well looked after, or they will leave the corn in the ear, and otherwise slight the work, in order to save themselves trouble.

(*c*). By task work: here each man has to thresh a certain number of sheaves, or produce a certain quantity of grain. This mode of proceeding is usually practiced in large farms where a number of laborers are constantly kept.

The farmer himself, or his steward, or bailiff ought to pay particular attention to the performance of this operation, or the laborers will leave the corn in the ear, cheat, and thieve; besides, these persons must maintain order, look after the threshed portions, and see that the grain is properly freed from all impurities, measured, and carried to the granary.

Various machines have been invented for the purpose of threshing corn, and many of them answer very well.

The best and most generally used threshing machine is one that was invented in Scotland, and which has since been greatly improved and modified. This machine beats the grain and chaff from the straw by means of a revolving cylinder furnished with flails or beaters; it separates the grain from the chaff, dust, and straw, and also separates the light from the heavy grains. This instrument has been made of various sizes; some are put in action by water, others by wind, and others again by two, four, or six horses. Their mechanism is complicated but durable, and, consequently, they are very expensive. There is however, a manufactory at Friederichswerk, in Seelande, where they may be obtained at very moderate prices: the large and complicated machines which require six horses to put them in motion may be had for 500 rix-dollars; and the smaller ones, such as are usually worked by two horses, for 180 rix-dollars. These machines thresh the corn very evenly, and in proportion to their size very quickly. The only thing which can be complained of is, that they break the straw; but this need not be rendered a ground of complaint, for it serves to make it better adapted for fodder and for litter, without unfitting it for other purposes. In those farms where threshing it an operation which should always be reserved for the purpose of keeping the men employed during the winter, threshing machines can only be of partial use; their advantage and utility is most evident at those periods when it becomes necessary to expedite the work.

With us the grain is usually stored up in granaries, most of which are over some part of the farm buildings, or what is still better, over open sheds. In very large agricultural undertakings, there are buildings set aside expressly for thir purpose.

The large massive buildings erected in Russia and Sweden for the purpose of storing up grain, are the best adapted for this purpose; in these the reservoirs are built in the form of tall chimneys, extending from the summit of the building to the ground; when completely filled, they are closed at the top so completely as to prevent all communication with the atmosphere; they are emptied at once by opening an orifice near the ground. The grain must have been perfectly dried in the air, or else in an oven or close stove, before being stored up in these places.*

In Ukraine the grain is still frequently stored up in pits and trenches, as used formerly to be the custom in Germany.†

After having been threshed, the grain should be spread out to dry on the floor of the granary: at first it should be laid in thin layers of about six inches deep, but afterward, when it has become tolerably dry, it may be collected more together, and left in heaps or layers of a foot or a foot and a half in thickness.

The time which has elapsed since the corn was got in, as well as the state of the atmosphere both then and subsequently, will guide the farmer in his after treatment of the grain. Where it has only been got in a short time, and where the weather is damp, it must be frequently turned and moved: at first it ought to be attended to twice a week; afterward only once a week; and in the summer, when it is tolerably dry, once a month will be quite sufficient.

A careful surveillance must be maintained in the granaries to prevent the mischief which is frequently done to grain by insects and vermin. No foreign grain should be admitted into the granary, unless it is ascertained to be perfectly sound, and free from insects. The walls of the granary must ke kept in perfect repair; they may be painted, provided that a brisk current of air can be kept up through the place to carry off the smell. When insects first appear, a strong current of air will frequently entirely get rid of them; but if they once get ahead; all that remains to be done is to sell the grain at the best price which it will fetch, and have the granary thoroughly cleansed and purified before any more is placed in it. Various substances may be strewed about it which are injurious and poisonous to the insects, as tobacco leaves, or a wash composed of a decoction of the leaves of the alder or walnut tree; turpentine, pitch, or tar may be inserted into all the clefts or crannies. But the most efficacious mode of proceeding is to burn sulphur in the granary several different times, and thus fumigate the place; if proper precautions are taken, this may be done without any danger of the building taking fire; every opening must be carefully closed up, or the smoke will escape and do no good.

Rats, mice, and weevils injure the grain very much, besides dirtying it with their excrements. Cats, owls and hedgehogs will sometimes diminish the number of these vermin; but they also dirty the grain. The use of poison for the purpose of their destruction is justly regarded as dan-

* "Norberg's Beschreibung eines Kornmagazins in den neuer Abhandlunger der Schwedischer Academie der Wissenschaften," Bd. X. A.

† "Schrebers Sammlung von Schriften zum Kameral Wissenschaft,'. Bd. X. A.

gerous; but there is a way in which recourse may be had to it without risk. The first thing to be done is to find some bait which these vermin are fond of, and place it in some spot close by the granary. When it is observed that they eat it with avidity, and devour all that is placed there at night before the next morning, some ratsbane or arsenic should be mixed with it; and thus all the rats will be destroyed in one night. This practice is not attended with the same danger as the dispersion of poison about the granary would be; for the animals who have eaten of the poisoned food set apart for them, do not return to the grain; they either crouch in a corner, or else run up on to the roof where they soon die. All the grain should then be raked, in order to see if any animal has dirtied it. If any of the poisoned food be left, it must be immediately removed; for should any rat be left alive, he will not touch it.

We shall now proceed to speak of the several species of grain; and, first, of corn, properly speaking.

WHEAT.

From the botanical genus *triticum*, arise four distinct genera which we consider as wheat, and cultivate in our fields, viz.:—

Triticum hybernum et æstivum	Winter or lammas wheat.
" *Spelta*	Spelt wheat.
" *Monococum*	One-grained wheat.
" *Polonicum*	Polish wheat.

The innumerable minor varieties derived from the first species, or wheat properly so called, are but degenerations or varieties which have undergone changes arising from extraneous circumstances. This opinion is contrary to the one usually entertained, even by botanists, who do not, however, agree with regard to the distribution of the species and varieties of the plants which we cultivate in our fields, and which are under the influence of art. They do not even agree about autumnal and spring corn. Although these two kinds, and especially some varieties of them, appear to differ so widely in their nature, they may, without difficulty, be rendered similar, if not wholly the same. If real autumnal wheat is sown in February, or about the beginning of March, a portion of its lateral offsets produce stems and ears which come to perfection the same year, though they yield but a scanty crop. If the grain thus obtained be sown on the following spring it will approach nearer to the nature of spring wheat, produce more stems and ears and ripen quicker; and if the grain arising from this second crop be again sown on the third spring, actual spring wheat will come up. On the other hand, if real spring wheat be sown toward the end of October, and a hard winter follows, in which the plants are not sufficiently covered with snow, the whole of the crop will inevitably perish; but if the temperature is favorable, it will succeed tolerably well, put forth ears, and ripen before the autumnal wheat. The grain obtained from it will, if set, produce plants that bear the winter better, and approach nearer to the nature of autumnal wheat, remain longer in the ground, and shoot up taller and stronger; on the following year it will have acquired all the characteristics of autumnal wheat, remain still longer in the ground, and shoot up still higher and stronger.

I cannot consider the *triticum compositum* (Egyptian wheat) as a distinct variety, since it loses all its numerous shoots, and its distinguishing characteristics, on being sown on poor land, as these arise solely from a superabundance of succulency. After this wheat has been reproduced several times on poor land, it ceases to bear the slightest trace of that multiplicity of ears by which it is distinguished. The grain, however, becomes larger as the number of the shoots decrease.

That which is termed *triticum turgidum* (turgid, or English wheat), is, perhaps, a distinct variety. The ears and the husk are peculiar, from their structure; the grain, from being wider at the back than any other, and from the absence of that velvety appearance at the round end which is observable in the grain of other wheat. This last-mentioned peculiarity was observed by Crome. Sometimes it is bearded; at others, not. I do not know whether the English distinguish it particularly from other kinds, there is so much confusion among their innumerable varieties. It certainly cannot be considered as one of the most common or generally cultivated varieties among them; the term English wheat, which we have bestowed upon it, is therefore inappropriate.

We shall hereafter speak of the different kinds of Spelt and Polish wheat.

The varieties of wheat are innumerable, especially in countries where very great attention is paid to the cultivation of grain, as is the case in England. I have reckoned more than a hundred kinds of wheat which are recognized by the English, and each of which has a different name; but all these are very frequently confounded, the one with the other.

Haller justly observes, that "the beard is a very uncertain characteristic, since in some soils wheat acquires a beard, while in others it loses it." The English, however, pay no attention to this circumstance.

The color of the grain is a much more definite sign. Red and brown, yellow and white wheat are always distinguishable from one another. The color of the straw, when it has attained maturity, does not always agree exactly with that of the grain. For instance, dark colored grain may frequently be seen growing on white straw, and *vice versâ*.

Brown wheat grows in countries where there is strong wheat land. When transplanted to other lands, it degenerates. It is as yet doubtful whether the wheat derives its red-brown hue from the soil, and whether or not it will lose it when sown in a different kind of land. If this change does take place, it is very gradually effected.

The kind which is usually sown in the autumn, and occasionally in the spring, is the yellow wheat. For some time this species had been wholly discarded by scientific agriculturists, and the white wheat adopted in its stead, on account of the latter yielding equally well, and likewise fetching a much higher price when once it began to be appreciated. It also forms a whiter flour than the yellow wheat, even when less carefully sifted. It is purchased chiefly for the use of the navy, and for ship provisions, and fetches a very high price. It would, in all probability,

have been pretty generally introduced, had not the winter of 1803 proved it to be exceedingly delicate. In many countries it could not resist the long period of dry, cold weather which then occurred, and perished, while the yellow wheat bore the severity of the temperature very well.

There are two kinds of white wheat. In one the husk is smooth; in the other it is covered with fine hair, which gives to the ear a velvety appearance. The English pay very great attention to this difference, as, according to them, it is not only invariable, but very important. The former kind they term *egg-shell wheat;* the latter, *velvet-ear.* They consider that the former answers better in damp situations than the latter, which, from its rough husk, attracts too much moisture, and, consequently, is exposed to the smut, and dries very slowly: on the other hand, however, the *velvet-ear,* or that which has this uneven covering, is considered as best adapted for dry, elevated situations, because it is better able to bear continuous heat than the other, does not dry up so soon, and is not so liable to contract. This opinion is doubtless well founded, since the little hairs with which its husk is covered may be regarded as suckers. A long while ago, I received some of this rough white wheat from England; I have since met with it in this country, and was informed that the seed from which it originated came from the principality of Dessaw; this also had, however, most probably been brought from England originally:* it has no beard. If any one kind of wheat more than another ought to be called English wheat, it is this, and not the *triticum turgidum.*

That variety which is so much esteemed in England, and which bears the name of *hedge-wheat,* and has been produced by the seed obtained from some large plants found near to a hedge, the which have become multiplied and perfected by careful cultivation, is by no means a distinct species, but will, if cultivated in the ordinary way, soon be found to decline and degenerate.

In the same manner, autumnal wheat is distinguished from spring wheat by cultivation and art rather than any botanical difference.

As it is of little consequence whether rye or wheat is sown for the autumnal crop, the question must be decided by the adaptation of the soil to one or the other of these products. Argillaceous soils should always be reserved for wheat; whereas sandy soils will be found best suited to rye. It may generally be admitted as a principle that land which contains more than fifty-five parts in a hundred of sand is by no means so well adapted for the production of wheat as it is for that of rye. There are, however, circumstances which tend to modify this principle—as, for instance, the position of the land, the sources from which it derives its moisture, &c. Where, from situation, the soil is inclined to be damp, it will be better adapted for the cultivation of wheat than for that of rye, even though it may contain from sixty to sixty-five parts in a hundred of sand; for the dampness, which compensates for the absence of clay, would be exceedingly injurious to rye.

The success of autumnal wheat can never be depended on, unless the ground upon which it is sown is tolerably stiff. Light, loose land, devoid of clay, may, if it is sufficiently moist, and contains an abundance of humus, produce wheat; but the crop is always casual and uncertain, because such a soil does not afford a sufficient holdfast to the roots, especially in the winter.

The greater the proportion of clay a soil contains, and the less proportion of sand, the more it is qualified for the production of wheat, and the less for that of rye. If land containing but little sand has fifteen parts in a hundred of lime, it may be considered as good wheat land; this lime tends to give it a degree of divisibility without at all injuring its consistency, and entirely prevents the development of that acidity which is so injurious to wheat.

But in order to ensure the success of wheat crops, the land must contain a sufficient quantity of nutritive particles to feed plants which require so large an amount of nourishment as these do.—Argillaceous soils, abounding in humus, and of a blackish brown hue, are consequently those, of all others, which bear the richest crops of wheat. Land which is naturally less fertile may be ameliorated through the medium of manure; clayey soils, however badly and scantily they may be manured, always bear better crops of wheat than of rye, especially when situated in a cold damp place; this is the reason that fields situate on mountains are always more profitable when sown with wheat than they are when sown with rye.

Wheat will not flourish if the soil contains any free acid; whenever I have met with land which, although apparently in every way adapted for the cultivation of wheat, yet failed to yield good crops, I have always found, on examination, that it contained a sensible quantity of acid.

Such land may be rendered fit for the production of wheat by ameliorations of lime, marl, or ashes, or by paring and burning the surface; after this last-named operation has been performed, it will prove equally adapted for barley, peas, or clover.

It may then be considered as an undeniable fact that argillaceous lands can be applied with far greater advantage in the production of wheat than in that of rye. But nothing but local circumstances and the state of the temperature can determine to which kind of grain a medium soil or thin clay, containing from fifty-five to sixty-five parts in a hundred of sand, is most favorable of production. In those countries where wheat constitutes the sole food, and rye is but little valued, the former is usually cultivated; but with us it is quite the contrary, wheat is only cultivated when particular circumstances combine to raise its price far above its relative value as regards rye. For although, on the average, such a soil, when kept in good condition, may produce a crop of wheat of far greater value than one of rye would be, it is well known that wheat exhausts land very much, and that its enervating effects are sensibly evident upon the succeeding crops: besides, wheat straw furnishes less substance for the reproduction of manure than any other. Thus wheat tends to enfeeble the whole system of the rural economy, especially when repeated crops of it are raised. Prudent agriculturists, therefore, content themselves with growing rye, from which they derive certain if not large profits.

Wheat is generally sown on fallow ground, or, if the soil contains little natural fertility, on manured fallows. Occasionally, when the land is very strong and rich, this practice is departed from, as there is then some danger of the corn being lodged; and a crop of cabbages, or some

* I found it, in 1811, sown in a marshy, damp soil; at least one-third of the crop was suffering from smut.

other produce of a like nature, is first raised from the land. Some agriculturists do not sow wheat even after this preliminary crop, but substitute for it winter barley, to be succeeded by a fallow or a fallow crop, and then sow the wheat. Others who are unacquainted with the advantages of the alternate cultivation of various crops, and attached to the triennial rotation, sow barley on the manured fallow, and then wheat. This barley is very frequently laid, but they are of opinion that it is less injured by this circumstance than wheat would be. The wheat which is then sown, so far from being very luxuriant and vigorous, is often exceedingly poor and weak. Barley forms by no means a good preparation for wheat; indeed, the soil must contain a superabundance of nutritive matter to admit of the wheat succeeding at all; on poor land it yields but a very thin crop. When the land is of a medium quality, wheat is almost always sown on a manured fallow.

This remark applies to *rotations with pasturage* as well as to the *triennial rotation*; and now most persons consider that it is most advantageous to sow wheat on the manured fallow which succeeds the rest, on account of the manure being most efficacious when spread over land which has been left at rest. The doctrine which teaches that a double force is productive of more effect than a single one, is by no means new; but the agriculturists of former days, who acted upon the system of rotations with pasturage, deemed it more expedient to distribute this richness of the soil over a series of years, and accordingly first profited by the amelioration induced by the rest, and subsequently by the manure. By this mode of proceeding they certainly did not obtain such exceedingly luxuriant crops; but, on the other hand, they had less wheat lodged in wet years, and, on the whole, realized a very considerable amount of produce. On many fields wheat was not then sown at all, while now it is sown as soon as the sward is broken up and manured.

Every fallow which is to be sown with wheat should receive four plowings, while those which are to be sown with rye need only receive three; for, although wheat requires a stiff soil, it also requires that all the nutritious matter should be brought within reach of its suckers, and the hard clods broken and pulverized.

In general, wheat is sown in the spring after turnips or cabbages; for, although there cannot be a doubt that these crops take from the land on which they vegetate a great proportion of its succulency, yet, as they are never sown but on rich soils which have been plentifully manured, they leave quite sufficient nutritive matter to ensure the success of the wheat. Indeed, these crops tend to give the soil a very efficient preparation for corn; they shadow it with their leaves, and render it loose and friable. Should it be deemed necessary, there is always time enough between the getting in of this fallow or preparatory crop, and the sowing of the wheat, to plow the land once or twice.

After some weeded crops which have been very plentifully manured, and have grown on particularly rich land—as, for example, tobacco or cabbages—wheat is also sown. The soil is then so loose and clear that this crop can be got into the ground with one plowing only; and, even when sown rather later than usual, succeeds wonderfully. Wheat sown after potatoes is, however, always poor and weak; this has been proved to be a fact by numerous well-attested experiments, although some agriculturists insist upon it that wheat crops thus obtained are equally as fine as rye crops would be.

Wheat sown after a crop of vegetables does not answer so well as it would if sown on a dead fallow. Nevertheless, there are cases in which, when thus sown, the crop has far surpassed that which would have been obtained from a fallow. Instances of this are chiefly observed when the weather has been unfavorable to the operations attendant on fallowing, but has greatly assisted in forwarding the growth of the vegetables, the debris of which then render the soil better adapted for the reception of wheat than it was after the fallow. But the soil, after having borne this crop of vegetables, must always be plowed previously to the wheat being sown, or the success of the crop will be doubtful.

Some persons consider peas to be the best preparation for wheat; others, on the contrary, prefer beans. The latter absorb more nourishment than the former, because they usually yield a much more abundant crop. Should the soil be only moderately supplied with fertility, it will, after having borne beans, be too poor to yield a good crop of wheat; peas would, therefore, have been better, as they would impoverish the land less. But, where the soil is rich enough to furnish the requisite nourishment to both crops, I think beans an excellent preparation for wheat. The rotation which has from time immemorial been followed in Kent, viz., wheat and beans alternately, proves the justice of my opinions; a similar rotation has also been adopted in various other parts of England. I have seen very fine wheat grown on land which had previously borne beans sown in rows.

Lastly, the best and most successful way of obtaining good wheat crops, is to sow the grain in broken-up clover land; but in order to grow it on land which, from its friability, appears not to be at all adapted for wheat, the best way is to sow the grain after one single plowing. It not unfrequently happens that the produce then yielded infinitely surpasses that of crops raised on fallow ground, and it is said to be less exposed to smut and other diseases. But these advantages will not be obtained unless the clover has been thick, vigorous, and unmixed with weeds: the second cutting taken sufficiently early to admit of the shoots acquiring a hight of eight or ten inches; and, lastly, the whole of this plowed in without having been pastured. These conditions can rarely all be fulfilled unless the soil happens to be particularly good, and great attention is paid to the whole of the cultivation. In breaking up the clover, care must be taken that the furrows are drawn straight, and the furrow-slices well laid over. The best way to ensure success is to make use of a light plow. The plowing must be performed a month before it is necessary to sow the grain, in order that the clover may have time to become decomposed, and the ground equalized. The seed may be covered by harrowing, but the best plan of proceeding is to make use of the extirpator for this purpose. This mode of sowing wheat on a single plowing is very seldom put in practice, except on clover land of one year's growth; nevertheless, if the clover is thick and vigorous, has been mown without being pastured, and the soil is clear and loose, the same course may always be pursued. Where, however, the contrary is the case, the land must be

plowed three times before it will be fit for the reception of the seed; consequently, only one cutting of clover can be obtained from it that year. General experience tends to prove that it is highly injudicious to sow wheat upon its own stubble. Tull, and some of his imitators, certainly sowed wheat year after year in the same field; but then he only derived a crop from one-half of the surface, and fallowed the other half. The same may be observed with regard to the Belgian system; but even there wheat is seldom or never seen on the same land for two consecutive years. Wheat sown after barley is always feeble: this plan of proceeding will only be found to answer on very good, strong land. Various experiments have appeared to prove that oats form a better preparatory crop for wheat than barley does. White wheat is considered to succeed better after brown, and *vice versâ*, than the same kind does when sown in two successive years. It may, however, be regarded as a general principle that it is in the highest degree injudicious to sow wheat on the stubble of any other crop of corn. Wheat sown after linseed rarely yields more than a very scanty crop, but it answers much better after hemp. I have, however, seen a very fine crop of wheat produced after linseed sown on ameliorated land which had only been plowed once.

There is no kind of corn in which the success of the crop depends so much on a careful selection of the seed as it does in wheat, for bad or defective seeds contain the principle of smut or diseases equally as fatal. We shall have occasion to enlarge more fully on this subject by-and-by, and will then enter into a consideration of the best method of purifying the seed.

Wheat is usually sown later than rye, not because it would be injurious to commit it to the ground earlier (for the experience of several countries teaches us that it may be advantageously sown in August), but because wheat is better able to bear a late sowing than rye; and, consequently, the latter is got into the ground first. Wheat also suffers less than rye when sown during wet weather; and this accounts for dry weather being always chosen for the purpose of getting the latter into the ground, while the former is sown either in wet or dry weather.

Wheat, when sown in an argillaceous soil, can bear a covering of earth three inches deep; and, where the land is light and loose, this depth may be increased to four inches: it germinates very well at this depth, and shoots up without difficulty. It may, therefore, without danger, be covered by a superficial plowing, provided that the soil is properly loosened, and not too damp: this plan of proceeding is peculiarly adapted to sandy soils, as the young roots of the corn are then enabled to take a firmer hold, and are less liable to suffer from the effects of drouth. The practice cannot, however, be carried into effect upon broken-up clover land.

Wheat withstands the wet weather usually met with in winter better than rye, and often shoots up again, even in places where, from there having been standing water, it seemed to have entirely disappeared. But, notwithstanding this, the fields should always be very carefully drained.

After an unfavorable winter, the wheat will often look very bad, even up to the beginning of May, and only a few plants scattered here and there will be discoverable. The farmer must not, however, on this account despair of the crop, but must wait until some weeks of continuous warm weather shall have given the crop a chance of recovering itself; should this fail to produce any beneficial effect upon the appearance of his fields, he may then have recourse to the plow, and break the land up. An account of some very interesting observations made on this point at Mecklenberg will be found in the "Annals of the Agricultural Society of Mecklenberg," vol. ii. 1803, p. 169.

Wheat requires more careful and continuous attention throughout the whole period of its vegetation than any other kind of cereal, and it amply repays all the labor and pains bestowed upon it.

If it is only just beginning to vegetate in the spring, and the soil is tolerably dry, nothing will prove so beneficial as to pass a harrow, having iron teeth, over it.* By this means the crust will be broken up which has been formed over the surface of the ground during the past winter, and the superficial stratum of the soil brought into direct contact with the atmosphere; the coronal roots which shoot about this time then find around them a soil recently impregnated with atmospheric matter, which tends greatly to favor the growth of the plants, while those weeds which shoot up at this season will all be then destroyed by the action of the harrow. A fine day should be chosen for the performance of this operation, which must be boldly undertaken. If, after this, the field has every appearance of having been newly sown and no green leaf, or, indeed, anything but the bare ground is perceptible, then there is every reason to hope that the operation will be attended with success. Should a few torn leaves or blades of wheat be perceptible, it will not matter, provided that the plants themselves are not torn up. After a lapse of eight or ten days, if the weather is favorable, the plants will be seen to shoot up afresh, and the field will present a much better and greener aspect than it did before the operation. The farmer may be pardoned anything but the omission of performing this important operation at the most favorable and propitious moment. Everything else should be set aside for the time being, in order that all the teams may be brought to work in harrowing the corn fields. The remarks relative to this point, which will be found in the "Annals of the Agricultural Society of Mecklenberg," are well worthy of perusal. No general rule can be laid down respecting the amount of draught power which should be attached to the plow, so much depending on the tenacity of the soil. The harrowing must be so complete that the field shall be entirely covered with a layer of loose earth, and those clefts which are usually formed in argillaceous soils when they become dry completely filled up. This operation need not be confined to tenacious clayey soils, but may be applied to land which is sown with wheat, without fear or hesitation; the only difference which need be made is, that light soils should be less violently harrowed.

There cannot be a doubt but that the operation of weeding, by means of which all the intervals or spaces which separate the plants are freed from weeds, cultivated and loosened, is exceedingly beneficial to the crops. But it is rarely performed, excepting in places where the farmer himself and his family work; or in localities where the laborers are accustomed to it, and execute it as

* Or else a rake with iron teeth.

task work. When the men are skillful in the performance of this operation, it is not nearly so difficult or laborious as at first sight it appears to be.

That species of cultivation bestowed through the medium of the hand-hoe is even more beneficial to the crops than weeding; it is not only more rapidly performed and less fatiguing, but the surface of the soil is thus loosened and ameliorated, and the earth raked up round the plants with less difficulty, and the plants themselves easily thinned, where they grow too closely together.

I shall presently have occasion to describe that kind of cultivation which may be bestowed by means of the horse hoe, and which can only be applied to crops sown in rows or lines, but which is so beneficial to wheat.

When, on a very fertile soil, the wheat plants, which before appeared to be rather few and far between, suddenly shoot up, and put forth vigorous leaves and lateral shoots, there is every reason to fear that the vegetation will become too luxuriant and the corn lodged.

There are two ways of avoiding this evil; viz., either by cutting off the tops of the plants, or by turning sheep on to the corn-fields.

When the first of these two is adopted, the tallest leaves are cut when the vegetation of the wheat is advancing, and it puts forth leaves and covers the soil; care must, however, be taken not to touch the heart of the plant. It is of the utmost importance that this operation should be performed by careful persons accustomed to mowing, and never by those to whom the portions cut off are to be given as fodder for their cattle; because, where such is the case, they are very apt to cut off too much, in order to obtain more food for their animals, and thus materially injure the wheat. The practice of cutting the leaves of the corn at this season, tends to check and temper the luxuriance of the vegetation. It must never be undertaken without due consideration and reflection. The farmer must be thoroughly acquainted with the fertility and other qualities of the soil and must carefully weigh all the appearances and probabilities from which any deductions relative to the weather and temperature which may be anticipated may be drawn; which latter are often very deceptive, since a state of temperature highly favorable to wheat is frequently succeeded by one which retards the vegetation of the crop so much, as to create regret that anything should have been done to weaken it. Nothing but practice and attention can enable the farmer to avoid frequently falling into great errors on this point. When the wheat plants are interlaced, the leaves of a dark green hue and intermingled with one another, when its shoots are full and vigorous and tall, some check should be given to the vegetation, if the farmer would avoid the danger of its being lodged; but where these appearances are not visible, it should be let alone.

The period for pasturing sheep upon wheat, usually, is about the latter end of April. This practice should, however, only be had recourse to when the soil is particularly fertile and the plants cover the ground with a thick layer of green. Where this mode of reducing the luxuriance of the vegetation is put into practice, a great number of sheep should be turned upon the land at once, and suffered to eat down the young plants nearly to the ground; it is highly injudicious to turn only a few of these animals on at a time, with the view of gradually producing the required effect. As soon as the sheep have performed their office, they must be removed, and the plants allowed to recover themselves. I consider that the best mode of proceeding is to cut off the tops of the plants; this, however, should be done only where the soil is very rich.

The operation of which I am now about to speak is somewhat analogous, although it should on no account be confounded with the last mentioned one; I allude to that in which the weeds that have shot up above the wheat, and rye plants springing from seed which chanced to be among the wheat or was contained in the manure, are cut down. This must also be very carefully done, and the wheat itself on no account touched.

Inclement and cold nights are more unfavorable to wheat than to any other kind of corn; they invariably check the vegetation of the crop, and almost cause it to retrograde. But the plants soon recover themselves. especially if a period of fine weather succeeds; a very few days will often suffice to make them again look green and healthy. Up to the time when the blades shoot and the ears become developed, wheat thrives best in a warm temperature varied by continuous rains, as such weather is most favorable to the growth of its lateral shoots. When it is about to flower, dry, warm weather is most favorable to it. After the grain is formed and matured, the most beneficial temperature is a moderately moist one; continuous drouth and warm winds mature the grain too quickly, and it is then not so perfect as it would have been under opposite circumstances. Heavy rains are exceedingly injurious, as they tend to engender smut in the grain.

Wheat which is intended for sale should be cut before it comes to full maturity, otherwise it assumes a dusky appearance, and does not yield such white flour; many persons endeavor to remedy this by moistening the grain, but buyers always reject such wheat, especially if the market is tolerably stocked. Besides, wheat is always disposed to shed its seed; in dry, windy weather, there will be some danger of a great deal being wasted if the crop is allowed to get too ripe. The exact period at which the harvest should be commenced must, therefore, be carefully chosen; and this has arrived when the grain has formed its farina, ceases to be milky, and yet has not hardened. Although wheat usually ripens about a fortnight later than rye, it frequently happens that it is fit to be cut before the rye crops have been gathered in. When this is the case, the rye should be left and the wheat gathered in, because if it is neglected the loss will be far greater than that resulting from any neglect of the rye would be; only that portion of wheat which intended for seed should be suffered to become completely or dead ripe, and this must then be gathered in as carefully and quickly as possible.

When wheat is sown in a good soil, and the weather is favorable to its growth, it yields the largest amount of produce of any kind of grain, in nutritive matter at least, if not in bulk; and then oats is the only kind which equals, or much less surpasses it. When only a moderate degree of cultivation is bestowed, it will often yield twenty-four bushels per acre, provided that the land is good, and the weather, on the whole, favorable. In England, wheat sown in drills, and carefully weeded, will often yield a much larger crop. Twelve bushels are usually regarded as a good, and

eight as a bad crop. On good wheat land, carefully cultivated, the average amount of produce is about ten bushels per acre per annum.

But we shall regard wheat as still more advantageous when compared with other grain, if we come to consider the value of its produce. This value is by no means conventional, but is, on the contrary, founded upon the nature of the grain. The usual weight of a bushel of good wheat is from 84 to 96 lbs., and this weight contains a far greater proportion of nutritive parts than an equal number of pounds of any other kind of grain; these parts, too, are in themselves superior, more strengthening, and energetic. It also contains gluten, that substance so analogous to animal matter, in much larger quantities, and in a much purer state than it is contained by any other kind of grain, and, consequently, wheat is most adapted for animal food. Besides, it contains particularly good starch. From the intimate combination of its particles, a far more digestive, nourishing, and agreeable kind of food may be manufactured from wheat than from any other kind of grain.

The condition and properties of the soil, as well as the kind and quantity of manure used upon it, has a considerable effect upon the relative proportions of the constituent parts of this kind of grain. Wheat grown on land manured by fresh sheep or horse-dung, or by these animals being pastured on it, always contains a very large proportion of gluten, which renders it unfit for the fabrication of beer or brandy, while it makes the best flour and bread. According to Hermbstadt, the proportion of gluten contained in wheat varies from five to thirty parts in a hundred. Besides this, all kinds of wheat have not an equally thick husk. This difference arises partly from variety and species, and partly from the nature of the soil; damp soils always make the husk thicker. The thickness of the husk is always exactly in an inverse ratio with the weight of the grain.

In proportion as wheat requires, and, under favorable circumstances, absorbs a larger quantity of nutritious matter from the soil than any other kind of grain, so in like proportion does it exhaust the land. In those calculations which I have already given, and which, although hypothetical are based on experiments made for the express purpose of throwing some light on this point, I have stated as a general average that wheat absorbs forty of every hundred parts of nutriment contained in the soil.

It is very probable that in the formation of its vegeto-animal gluten, it absorbs a large portion of animal humus, or, at any rate, requires a large quantity of azote; and that animal manures suit it much better than those which are purely vegetable, and which suffice for any other kind of cereals. Lime and alkalies might answer as well; I say might, for as yet we have no positive experiments on this point to prove that they do. Most certain, however, it is that wheat exhausts land much more than any other kind of grain; both general experience and individual experiments tend to attest the truth of this fact. The cultivation of it should, therefore, be restricted within certain limits, especially where the land is light and friable, as in these cases the humus contained in it is much more easily absorbed than it would be from a clayey soil. Where the circumstances of the undertaking are such as to admit of the exhaustion being repaired by the addition of fresh manure, the farmer can be guided by his own interest or pleasure on this point.

Wheat usually gives double the weight of straw that it does of grain. On elevated or mountainous lands, something less—and on low, flat grounds, something more this average may be anticipated. The weather has a considerable influence on on this proportion in wheat as well as in all other kinds of grain. Wheat straw is more nutritious than any other; but it is not so well adapted for litter as rye straw.

Spring Wheat.

This kind is not distinguished from autumnal wheat by any botanical characteristic, but simply by a property which has been artificially communicated to it, and of which it may be deprived by a change in the mode of cultivation, viz., that of coming more quickly to ear. It is not always bearded. It is well known that spring wheat is often made to become autumnal. This cannot, however, be so easily effected with some varieties as it may with others.

Various kinds, both with and without beard, have been cultivated. The beardless varieties have generally been considered the best. It will be impossible to decide whether or not certain kinds of wheat brought from Tunis or Candia, and cultivated by Fischer, at Dunkelsbühl, are deserving the high praise bestowed on them, until some more conclusive experiments have been made on the subject.

Spring wheat does not require so stiff a soil as autumnal wheat, but thrives well on light land, provided that this land is not too dry, and is also rich in humus and manure. It also must be well tilled, pulverized, and cleared. The fields in which spring wheat can be sown with most chance of success, are those in which weeded crops have been cultivated, and where autumnal wheat has not been sown, either on account of the weeded crop having been got in too late, or because it in general forms a very bad preparation for spring corn.

Spring wheat succeeds better than autumnal wheat when sown after potatoes, provided that the soil is rich, and not too dry. In general it takes the place of large barley. Many agriculturists consider it to be exceedingly advantageous always to sow spring wheat instead of large barley after weeded crops, where the alternate rotation is pursued, because its produce will invariably be found to be greater than that of barley; but the result has not justified the opinion, excepting where the soil has been rich, and abundantly stored with humus. There can be no doubt but that spring wheat absorbs more nutritious matter than barley. Where the soil is poor, the crop fails; and where it is rich, it thrives and exhausts it. Autumnal wheat, which is not sown until two years afterward, and even the succeeding rye crops will yield but a scanty produce, unless the exhausted land is ameliorated by good manuring.

To these remarks it may be added, that spring wheat is very apt to fail in our climate. Cold, rainy, and even dry summers are injurious to it. In those years when, from a succession of alternately warm and dry weather, barley thrives very well, at least half the wheat ears will be found to be destroyed by smut. This disease attacks spring wheat much more frequently than it does autumnal wheat; whereas caries seems to be peculiar to the latter. This circumstance may pos-

sibly account for the fact, that notwithstanding the praises lavished on spring wheat, it is but little cultivated in the north of Europe; indeed, it is seldom met with there, excepting in those places where autumnal wheat is not cultivated.

The period for getting the seed into the ground occurs some time between the middle of April and the middle of May; it should not be sown so early as spring rye; it does not in general ripen until September. The grain is smaller, and does not make so much show as that of autumnal wheat. The husk is usually stronger, and the grain lighter, although the farina which it yields is fully equal in quality to autumnal wheat. Some persons are of opinion, however, that it does not answer so well as the latter when used for the purpose of making bread, but speak very highly of its qualities when employed in the manufacture of starch.

When wheat is scarce, buyers frequently do not object to giving as much for spring as for autumnal wheat; but otherwise they reject it, and not entirely without reason, on account of the smallness of the grain, and that it fetches but a very low price.

Spelt.

Triticum spelta is chiefly distinguished from wheat by its husk, which is flat, and round at the end, and encloses and retains the grain so firmly that it cannot even be separated from it by threshing; recourse is, therefore, obliged to be had to a mill. It is, doubtless, this circumstance which prevents this useful grain from being cultivated in the north of Germany, where the millers are unacquainted with the means which must be taken for the purpose of freeing the grain from the husk or chaff.

There are various kinds of spelt; some with and some without a beard; some grown as autumnal, some as spring corn; and these varieties differ in hue and color.

There is no difference between the cultivation of wheat and that of spelt. The latter is stronger, and less liable to fail during winter when sown in damp situations than wheat: it grows higher, is not so easily laid, and does not shed its grain so quickly; neither does it require so rich a soil. It is, like wheat, subject to smut; but does not suffer so much from the ravages of that disease. When the grain is separated from the husk, it is quite equal to wheat in weight and value; some persons even assert that wheat does not yield so good flour, or make such nice bread as spelt.

It is either preserved in the husk or separate from it; it is, however, seldom separated from it, unless it is to be used immediately, as it keeps better in that covering, and is less liable to be injured by vermin, or become heated. Sometimes it is sent to market in the husk, at others not until freed from it; in the former case, it only fetches one-half as much as it does in the latter.

It is sown in the husk, but twice as thickly as wheat. In the south of Germany it is more generally cultivated than any other kind of grain.

When in the husk, it may be advantageously used as provender or forage for horses; and in places where the millers are not acquainted with the proper mode of separating the grain from the husk, this is the best if not the only use to which it can be applied.

One-grained Wheat (Einkorn of the Germans.)

Triticum monococon, or Saint Peter's wheat, very much resembles large flat barley, in its general appearance and in the form of the ear, but it has not so much beard. The grain is equal in value to that of spelt; but it is much smaller. It is cultivated both as spring and autumnal wheat, on land which is regarded as too poor to bear spelt; also on the most remote crop divisions, and in places at a considerable distance from the farm buildings. It is most frequently met with in Wirtemberg.

The species known to botanists *triticvm polonicum*, Polish wheat, Valachian wheat, Surinam wheat, &c. has been derived from the *triticum monococon*. This variety differs from all others in the form of its ears and grain, both of which are long and narrow. The quality of the farina is about half way between that of wheat and rye flour. It ripens late, when, as is usually the case, it is cultivated as spring corn; in cold summers it rarely attains to maturity. It is much prized as an ingredient in soup, after having been ground, and is said to approach nearer to the nature of rice than any known production. It has not yet been made a marketable commodity among us, nor do we expect to see it so.

Smut or Caries in Wheat (Brand.)

In the cultivation of wheat, and other species of the family of *triticums*, there is, in some countries, nothing that militates so much against the success of the crops as those diseases termed "smut" and "caries;" and, consequently, no subject has so deeply engaged the attention of agriculturists, as the means of guarding against this evil. Numberless volumes have been written on this subject in every known language; but, as yet, very little light has been thrown upon it, on account of the disease having been confounded with others which are essentially distinct and arise from totally opposite causes, or else because each author has given his own views and opinions only, without reference to those of others, and these have been too frequently founded on narrow and partial views of the subject.

We shall commence by drawing a line of distinction between these two diseases, both of which are, in Germany, comprehended under the denomination of *brand*; the first, or *brand* properly so called, is that disease which the French designate "*nielle*," and the English "*smut*." It entirely destroys the substance of the grain, and nothing remains in the husks but a blackish brown dust. This disease is, doubtless, the same as that which develops itself in various kinds of grain, and especially in barley and other gramineous plants, and which is frequently designated "soot," because the powder to which the grain is resolved so much resembles that deposited by flame, and is, in fact, fully capable of supplying the place of actual soot in the preparation of the black color used in painting. This disease attacks wheat more frequently than any other kind of grain, and often destroys the greater part of the crop. I have seen a field of spring wheat, sown

on a recently manured sandy soil, in which I could not discover one single perfect grain.* It often shows itself before the ears have begun to form, and traces of blackness and disease are visible even in the very marrow of the plant. Where this is the case, however, the plants grow up to their usual hight, the ears attain their usual size, and even look healthy, although they are thin and poor. The husks are greener, shorter, and rather more rounded. When the ear is approaching its full sibe, the black hue becomes perceptible through the husk; which latter is not, however, so thin as in barley, where it bursts before the formation of the ear is nearly completed, and sheds a black dust. When the wheat has attained its full growth, the husks burst, and the rain and wind wash away and carry off the black dust, without its injuring or discoloring the sound grain. But where the wheat is cut before it has become perfectly matured, and the weather is damp, the powder remains in the husk, is carried to the barn with the wheat, and there beaten out by the flail. In this manner the sound wheat becomes blackened, because this black powder attaches itself particularly to that slight tuft of hair or down which exists at the extremity of wheat, at the bottom of the line or cleft which passes down each grain. This discoloration, notwithstanding which the grain remains uninjured, is called the tip *(le bout den nagelbrand, der spitzbrand,)* and is very often confounded with caries. But it is neither more nor less than a mere external discoloration of the grain, and has not the slightest effect on its soundness; it cannot, however, be denied that it may tend to give a black shade to the flour, unless the grain is very carefully cleansed before being sent to be ground. There are two ways of cleansing the grain; the first consists in washing it, and does not injure it in the least, provided that immediately afterward it is carefully dried; the second consists in threshing the grain, mixed with barley chaff or dry clay, and subsequently separating it from these substances by passing it several times through a winnowing machine.

The disease itself is not hereditary, nor is it transmitted through the medium of the seed; it is engendered on moist or exceedingly rich land when the weather is damp and warm. It is true that an imperfect grain will produce only a feeble plant, and such an one will undoubtedly be more liable to take disease than another would be; but still the disease is not hereditary in the actual sense of that word, and for this reason: those grains which actually are attacked by this disease are completely destroyed, and the powder which falls from them adheres merely to the exterior of the others, and does not injure them in this point of view. Sound grain which is only discolored by this smut powder will always produce healthy crops, provided that there are no other circumstances attending it which lead to an opposite result. My own experience, as well as that of others, tends to prove that not only the ear, but the whole of the grain is attacked by smut. No washes can impede the progress of the disease; the best way of preventing its attacks is to see that the seeds are sound and fully matured, the sowings properly performed, the soil thoroughly drained, and that species of manure applied which is best adapted to its nature. The weather and temperature exercise considerable influence over this disease; in one year it will be scarcely heard of, while in another its results will be most fatal. There are some particular fields in which the crops frequently suffer from caries, and where smut is unknown; while in others the the former disease may be guarded against, while the latter can never entirely be eradicated.

Caries does not wholly destroy the consistence of the grain, nor does it injure its form; nevertheless, its blackish-brown hue, its smell, and its nauseous flavor are sufficient evidences of change and deterioration. This disease does not appear to be developed until the grain begins to form; no traces of it are perceptible until after the period of flowering. The ears look sickly, pallid, and weak, and eventually become covered with dark-colored specks. Caries deteriorates the sound grain when any of the diseased ones are suffered to get among it; but as those which are attacked are lighter than the others, it is easy to get rid of them by the process of winnowing. When this operation is carefully performed, the greater part, if not the whole, of the diseased grains may be separated from the sound ones. Where only a few are left, they do not spoil the flour or render it injurious to health; but where there are any considerable number of them, they communicate a disagreeable flavor to it, and render it unfit for any kind of use. The grain even becomes less adapted for the use of brewers and distillers, and deteriorates from the quality of the brandy made from it.

The cause of caries, at least of the most virulent variety of this disease, exists in the seed, and is hereditary. This is sufficiently attested by the fact, that many agriculturists whose crops have year after year suffered from its ravages, have only succeeded in escaping from this evil by a most careful selection of the seed, and by following it up with other suitable preventive proceedings; but no sooner have they ceased to observe these precautions, than the disease has returned as badly as ever.

When perfectly ripe grain which has never been attacked by this disease, has been threshed previously to being sweated in the stack, is then spread over the granary in thin layers, carefully moved about to expose it to the air until dry, and then sown, the farmer may make himself perfectly easy respecting the success of his crop, at least so far as regards this disease. All danger may frequently be avoided in grain a year old, which has been properly treated and carefully preserved.

If, however, this cannot be entirely depended upon, there are various means of preventing or lessening this evil, all of which are attended with greater or less success.

Some persons consider it as sufficient to wash the wheat in clear water, provided that while doing so, care is taken to remove all the light and diseased grains, which invariably rise to the top.

Others regard salt water as more efficacious; the light grains being then more sure to swim on the top; besides, it cannot be denied that salt also acts beneficially in another way.

The most really efficacious preventives have been found to be lime, ashes, common salt, glau-

*From this it would seem that this disease is much more frequent and dangerous in the north than it is in the south. I have never seen it commit anything like the ravages above described, either in Italy, France, or Switzerland. [*French Trans.*

ber and other salts, alum, sulphate of iron, and arsenic. These substances are used either singly or combined, in various forms and ways.

The following is the most usual way of applying lime:—One bushel of recently slaked and pulverized lime is considered as sufficient for twelve bushels of seed. The grain is washed with cold water, from which the chill has been taken: some agriculturists use urine. It is thrown into this fluid and well stirred about until all the light grains float on the surface; these must be skimmed off and thrown aside as useless. The wheat thus steeped should then be drained for a little while, and afterward powdered with the newly slaked lime; it should then be left untouched for eight or twelve hours, and then stirred up thoroughly, spread out in thin layers over the floor, and left to dry; it must not be put into sacks until thoroughly dry. Many agriculturists take equal parts of lime and alkaline ashes, and thus produce a caustic alkali, which mixture, whether viewed in a theoretical or practical point of view, appears to be highly efficacious. Some persons also add a greater or less proportion of common salt. A wash is also made composed of lime, ashes and urine, to which common salt is occasionally added, and the grain watered with it. There are various manipulations and modes of proceeding in these cases; and, although each person attaches particular importance to his own plan, they are all much the same in point of effect. The chief thing to be attended to is to see that these pickles are made as strong and active as possible, and that the whole of the grain is so thoroughly stirred about that each individual seed receives its due share. The grain must be left under the influence of this mixture for a certain time, and until a slight degree of heat is perceptible and then spread out and exposed to the air. Some persons regard kitchen salt as exceedingly efficacious, and, consequently, depend chiefly upon it: but the best authenticated and most numerous experiments tend to prove that no substances so fully answer this purpose as lime and ashes; and in most countries these are the cheapest which can be obtained.

Solutions of vitriol and alum have been very highly recommended; but as there are as yet no authenticated proofs of their efficacy, we shall not put them on a par with the other matters.

Arsenic is a very efficient, but also a very dangerous substance, to make use of, and, when employed, must be confided to the care of some person who is perfectly aware of the frightful effects of this subtle poison.

Although these two diseases, smut and caries, are completely distinct in their nature, it not unfrequently happens that both are found existing in the same field; and although it has been proved that the principal cause of caries is in the seed, and that by a careful selection or treatment of the seed it may frequently be eradicated, yet it must be confessed that it will often be engendered, even where the seed has been perfectly sound, by various causes which exercise a peculiarly pernicious influence over vegetation; and, consequently, there is no certain means of guarding against it.

RYE.

Secale cereale (common rye). Of this grain we have but one species, and all its numerous varieties are distinguished by no botanical characteristic, but merely by some difference in their nature, occasioned by peculiarities in the mode of cultivation.

Autumnal and spring rye acquire the properties that give rise to these appellations, in the same way as autumnal and spring wheat do: we have already described this. The following are the properties of autumnal rye: it remains longer in the ground, grows more bushy, and does not put forth its stems or seed stalks until late in the season. We have one variety which came originally from the Russian provinces on the shores of the Baltic, and which has all the properties of autumnal rye. Those varieties known by the names of *Archangel rye, Norwegian rye, St. John's rye, &c.* are one and the same, and no dissimilarity between them can be discovered.

I cannot yet make up my mind whether or not the kind termed *Wallachian rye* is of a different nature. It is more than probable that there has been some mistake respecting it; for fifty years ago Siberian barley (*hordeum cæleste*), was regarded as a species of rye, and called Wallachian rye; and not six years ago some of it was sent to me under that name. The real Wallachian rye has no distinguishing characteristic. Every kind of grain which is for some years subjected to a mode of cultivation similar to that pursued in gardens, and the seed of which has been carefully selected, undergoes some changes in its nature; but it is not difficult to foresee that when it comes to be again cultivated in the open field, the existence of these alterations will be of short duration.

That kind of rye which comes to us from the Russian provinces on the borders of the Baltic, and the German name of which may be translated "bushy rye," is far superior to others. It resists inclement weather better, grows fuller and higher, is not so easily laid, and when sown on a good soil with proper care, always yields a large amount of produce. It must, however, be got into the ground before the end of September. If sown later, or on poor ground, these advantages will not be so manifest. It puts forth its blade and stems, flowers, and ripens much later than common rye; and in order to have it ready for reaping about the same time as the other, it must be sown very early. This variety undergoes no alteration. I have been unable to perceive the slightest degeneration even when it has grown near enough to other kinds of rye to receive the pollen blown from their stamens.

Land containing a large proportion of sand is best adapted for rye, which is the only grain that can be cultivated on a soil containing eighty-five parts in a hundred of sand, or more. With us, land of this nature is always called rye-land. Soils containing less than eighty-five parts in a hundred of sand are also adapted for that production of rye.

The richer the land, the more vigorous and luxuriant will the rye be. This grain, however, answers on poor land, which wheat does not. But this depends much upon the nature of the land. Sandy soils part with their humus so much more easily than clays do.

If an exhausted field or portion of land be left in repose for some years, it will collect sufficient nutrition to enable it to bear a crop of rye, though it must be admitted that it will only be a poor one.

Neither is rye so liable to be injured by any acidity in the soil as wheat or barley would be, and consequently, it may be cultivated on marshy, or heath and furze land, which has been drained.

Rye may therefore be regarded as the most precious gift of God to the inhabitants of sandy and poor countries; without it, many districts would have been uninhabitable.

The degree of preparation bestowed on the soil, and the nature of the crop which precedes the rye, are not of so much consequence as these points would be if wheat were to be sown. A sandy soil, such an one as is best fitted for the production of rye, requires but three plowings; while more tenacious soils amply repay the expense of a fourth, by the increased amount of produce which they then yield.

Those preparatory crops which are advantageous to wheat, are equally so to rye when it is sown on the soils on which they can be cultivated. A diminution in the produce of the rye crop is almost invariably observed when it is made to succeed potatoes or linseed.

Rye bears being sown on the stubble of some other grain, or even on its own, much better than wheat does. It is also well known that in some countries rye is sown three or four times in succession on the same land; but the crops thus raised are so miserably poor that all unprejudiced persons have discarded such a rotation. Not even rich and repeated ameliorations can prevent the produce in grain from falling off sadly, although the straw may vegetate luxuriantly. All those isolated cases which are brought forward for the purpose of proving that the second crop has been finer than the first, and of defending this mode of proceeding, cannot overcome general experience, and might, if investigated, be very easily explained away. New manure, buried a short time only before the sowing took place, and the decomposition of which had been prevented by drouth or humidity, would always be injurious to the first crop, while it would favor the vegetation of the succeeding ones.

This mode of proceeding may, however, be excused, where the ground is only fit for the production of rye, and where straw is worth as much or more than grain.

It is true that it is not absolutely necessary to pay so much attention to the choice of the seed for a rye as for a wheat crop; nevertheless, perfect and ripe seeds, free from disease, will always fully repay the attention bestowed on their selection. Rye can only bear a very light covering of earth: if sown too deeply in the ground, and especially where the soil is tenacious, it will often be unable to germinate, and will perish. This is the reason why it is so dangerous to bury rye with a plow: I have experienced this to my cost. If the soil is very dry, and remains so after the sowing has taken place, rye sown in rows may have some advantages over that which has been sown by broadcast, because it shoots up more evenly and equally. But as the kind of temperature which will succeed to the sowings cannot be foreseen, it is always most prudent to have recourse to the harrow, unless the seed is to be buried by passing the extirpator superficially over the ground, which mode of proceeding is certainly preferable to any other.

In our climate, the best time for getting the seed into the ground is somewhere between the middle of September and the middle of October. In some countries, however, the rye is sown in the open field during the whole of the winter, and even up to the end of February, and at times with great success. This is done to enable it to benefit by the ameliorations bestowed on the land in the winter.

Many impartial observers assert that the latest sowings are those which can be most depended upon; but, on the other hand, the crops are never so large as those obtained from earlier sowings where they do succeed. The worst period for getting the seed into the ground is from the middle of October to the middle of November. But the *bushy rye*, of which I have already made mention, must always be sown early in the year; in fact, it can scarcely be got into the ground too soon. I have even sown it in the middle of June without its coming up that year. When not sown until October, it grows very feebly; and its lateral shoots, being behindhand when the ears begin to form, remain poor and weak.

From eighteen to twenty metzen of rye are generally sown per acre. When bushy rye is sown in August, or about the beginning of September, from twelve to fourteen metzen of seed will be quite sufficient, if it is sown evenly and regularly. It grows so full and luxuriantly that three-fourths of the plants are choked, and but one-fourth remain. In the spring the fields often look so clear that those farmers who are not accustomed to this grain blame themselves for having been too stingy with their seed. But it would have been just the same if they had sown it more thickly, for in the autumn the plants increase and grow so full that they push against each other: each one puts forth ten or twelve blades or more, and, provided the soil is rich and the weather favorable, the whole field appears closely covered with a luxuriant crop. As this kind of rye comes up, puts forth its leaves and shoots much later than any other, it often, in May, appears to be very much behind other crops in point of vegetation, but before June is over it has far surpassed them.

Rye crops are equally as much benefited as wheat by being harrowed in the spring, especially where a hard crust has formed over the surface of the soil; but this tillage or cultivation is never bestowed on it. Harrowing is exceedingly beneficial to rye, even where the soil is of a very sandy nature; but in these cases the operation must be performed with light wooden harrows, and not until the plants have put forth their strong roots. Where these latter have been torn up by frost, especially from a spongy soil, or uncovered by the wind, it will be better to use a roll.

The flowering season is a more critical period for rye than for any of the other cereals; nor can the farmer reckon with any certainty on the success of his crop until this has passed. A white frost coming on about the flowering time may wholly or partially prevent the formation of the grain. This evil frequently only attacks the hedges of the field, or those parts most exposed to the wind, and frequently only injures one side of the ears, viz. that one next to the quarter whence the wind comes. Where this has been the case, the ear loses color, the points of the husks pucker up, and the husks are found to be empty.

Rainy, damp, or very windy weather, occurring about the flowering season, has a pernicious influence on rye. Occasional showers do it no harm, even when they are tolerably frequent, provided that there are a few hours of warm, sunny weather between each; for during rain the rye

closes up its valves, and when the sun afterward comes out, the anthers spring up so vigorously that the pollen from the stamens covers the field like a thick cloud. But during continuous rains the anthers undergo an alteration in the valves, and rot; or, at any rate, impregnation does not take place; or if it does, the embryo of the grain is putrefied and lost. It is thus that the disease termed the spur or ergot of rye is engendered, and that curious, blackish, violet-colored excrescence formed which is so well known, and of itself appears to be of no consequence, but when swallowed in large quantities, and especially while fresh, occasions such dangerous and mortal diseases in both men and animals.

Strong, vigorous rye is, however, better able to resist the influences of foreign causes even during the flowering season, than weak and sickly plants are.

When the flowering time is over, it will be easy to discover whether fecundation has been accomplished or not, or, in other words, whether or not the husks contain their grain: it is only necessary to hold the ears up to the light in order to ascertain this, because the impregnated valves appear transparent. But as with rye the flowering process proceeds but very slowly, it is as well not to be in too great a hurry to calculate the probable success of the crop, lest we form an erroneous judgment. When the plant is farther developed, the empty husks will be felt on passing the hand over each ear.

Rye is ripe when the straw becomes pale; when its yellow hue fades almost to white, and the knots have lost every trace of green: the grain is hard, easy to be detached, and falls out on the plants' being struck or shaken. But Cato's maxim must always be observed with regard to rye: *Oraculum esto biduo citius, quam biduo serius metere,* (get in your harvest two days too soon rather than two days too late).

On land of tolerable quality, and which from its nature is as well adapted for rye as for wheat, the average produce of these two kinds of grain will be nearly or quite the same in volume. I have, however, never known an instance in which a rye crop averaged more than twenty-two bushels per acre; while much larger crops of wheat are frequently obtained, although it must be confessed that it was from land much too stiff for rye. Twelve bushels may be regarded as a very fair amount of produce; but now and then the crop barely yields three bushels per acre. Where it is less than this, it may be said altogether to fail; a soil on which this is usually the case, hardly repays the expense of sowing it, and has no nominal value as arable land.

The weight of a bushel of good rye is from seventy-six to eighty-six pounds.

Next to wheat, rye may be said to contain the largest amount of nutritive matter of any of the cultivated cereals. It contains an aromatic substance, which seems to adhere more particularly to the husk, since that agreeable taste and smell peculiar to rye bread are not perceptible in that which is made of rye flour that has been passed through a very fine bolting cloth. The smell, as well as the blackish hue, may be restored by means of a decoction of rye bran in warm water used in making the dough. This substance appears to facilitate digestion, and has a peculiarly strengthening, refreshing and beneficial effect upon the animal frame.

In places where rye is the chief article of food, the price of this grain is not so variable as it is in others, or, at any rate, it remains more in accordance with the abundance or scantiness of the crops. Foreign demand has in this country but a very indirect influence on its price. With us, rye regulates the price of all other products; and even, by the wages of manual labor, the price of all kinds of manufactured commodities. The circumstances of the locality may be such as to render it more advantageous to grow other products, but the demand for rye is always most regular and certain.*

All soils containing an excessive proportion of sand, and which are not too much exposed to humidity, will be found to bear better crops of rye than of any other kind of grain, provided that the sowings are carefully executed.

This grain exhausts land much less than wheat. In a previous section we have admitted, as a general principle, that rye absorbs thirty parts in a hundred of the nutriment contained in the soil. As this grain yields a larger quantity of straw than any other, it will, if this straw is reduced to manure, restore a larger portion of the nutriment which it has absorbed than any other; besides, its straw is peculiarly adapted for all the purposes of an agricultural undertaking.

Spring rye is simply a variety of autumnal rye, and may, as I have before observed, easily be changed into autumnal rye. It is generally made use of to replace the latter, when it has been impossible to sow the seed in time; and the ground is not fit for any other kind of grain, and especially for the purpose of deriving benefit from the manure bestowed on the soil during winter. It thrives well on land which is too sandy and too dry for barley or oats. After potatoes or autumnal rye which has failed, spring rye succeeds admirably, provided that it has been sown as early as possible, and in a soil properly prepared for its reception.

Spring rye otherwise seldom yields an amount of produce at all equal to that of autumnal rye, and sometimes altogether fails. Its grain is small, and has a very thin husk; but contains such excellent flour, as to cause it frequently to fetch a higher price than autumnal rye.

It ought to be sown early, viz. either at the end of March, or about the beginning of April; autumnal rye should be sown at the commencement of March. Spring rye is not unfrequently sown on the stubble of autumnal rye, after an amelioration of fresh manure. The soil is only prepared for this kind of sowing during the cold and wet winter months; consequently, dog's-tail grass, bent grass, and other varieties of *agrostis*, multiply rapidly. In general, no fields are found to be so infested with weeds as those in which rye is chiefly cultivated. Such land has hence, often, and very unjustly, been accused of being disposed by Nature to produce bent grass.

* This remark is chiefly applicable to the north of Germany, or to countries where the inhabitants live chiefly on rye, which is not generally the case either in France or Switzerland. [*French Trans.*

BARLEY.

There are five, or, some say, six species or subspecies of barley actually known and cultivated among us—

1. *Hordeum vulgare*..............Common or spring barley.
2. " *distichon*............Two-rowed or long-eared barley.
3. " *celeste*................Siberian barley.
4. " *nudum*...............Flat, naked barley.
5. " *hexastichon*...........Six-rowed or winter barley.
6. " *zeocriton*.............Sprat or battledore barley.

All species of barley require a light, rich, loamy soil, which retains moisture, without, however, suffering from damp; a soil which contains from fifty to sixty-five parts in a hundred of sand, and the rest chiefly clay. If having the former of these proportions it is situated in a dry position, and having the latter in a moist one, it will be rendered still more adapted for the production of barley. This kind of grain, however, thrives wonderfully well on more clayey or stiffer soils, where there is a sufficient quantity of humus to prevent the land from being too tenacious; in short, in land which may be classed among good wheat lands. If the clayey soil contains a certain quantity of lime, and the proportion of clay in it is sufficiently diminished to render it light, without ceasing to be consistent, it will then be peculiarly adapted for barley; and the more so from the lime purging the soil of its acidity, which latter quality militates against the success of barley. On the other hand, in moist summers, barley will be found to succeed very well on land in which sand is the predominating ingredient, and where it is found in the proportion of from 70 to [illegible] parts in a hundred; provided, however, that the soil is in tolerably good condition. But during dry summers the crops of barley would fail on such land; consequently its produce can never be depended on. A poor, tenacious, moist, cold, acid soil is by no means proper for barley, nor will that grain often succeed when sown upon it.

Land in which barley is to be sown must be thoroughly loosened and pulverized. When, as usually happens, it is sown on the stubble of autumnal grain, the land must be plowed at least three times for its reception; but where the soil has been thoroughly loosened during the preceding year by weeded crops, one plowing will be quite sufficient.

If those crops by which the barley was preceded have not left a sufficient, or indeed a considerable quantity, of nutriment behind, an amelioration composed of manure which has undergone fermentation must be bestowed upon the soil. The tender nature of this grain renders it necessary that the nutrition intended for it should be easy of digestion, and properly prepared for and adapted to its organs.

Barley is not exposed to any particular disease excepting smut, and that seldom injures it much. Those ears which are attacked by it are chiefly the early ones, and then it appears as if the whole field was covered with diseased plants; but when the healthy ears attain maturity, scarcely any trace of the others remain. Pickling and liming have no effect on this kind of smut whatever.

All those kinds of barley which are usually sown in the spring, support and require a tolerably thick covering of earth; they may be buried by a shallow plowing of three or four inches deep, and, in fact, when sown on a very light soil, must be placed at this depth beneath the surface. The land, however, must always first be allowed to get thoroughly dry; with us nothing is more conducive to the success of this grain than a period of dry weather succeeding to the sowing.

Perfectly ripe seeds which have not become heated in the granary will always produce healthy plants; they must, however, be carefully sifted and washed, to separate them from those seeds of weeds which usually grow so fast among barley. When this has been done, and the seed is sown early, twelve or fourteen metzen per acre will answer as well as twenty or twenty-two would otherwise do, especially where large barley is sown.

Barley becomes very thick and bushy where it has sufficient space, but when crowded the plants are weakly. Small barley may be sown much more thickly, as the plants are never so full and bushy as those of large barley.

Should heavy rains, which harden the ground, come on after the seed has been sown, a harrow must be passed over the soil as soon as it becomes dry, and before the barley begins to spring up, in order to break the crust, which otherwise often impedes the growth of the plants, being too hard to admit of their forcing their way through.

After the barley has begun to appear above ground, it is often very dangerous to make use of the harrow, as the plants are as brittle as glass. This operation, if performed at all, must be very carefully managed; a light wooden harrow used, and the latter part of the day or the evening chosen for the purpose.

Common, or spring, or small quadrangular Barley.

This species is regarded as best adapted for poor land, and hence has been designated the barley of sandy soils; it will, however, succeed equally well on clayey soils, provided they are rich and the weather is favorable to it, but not better than large barley. It has six rows, and consequently its ear is in the form of a square, having two wide and two narrow sides.

It is very delicate; a sharp frost will destroy it, and it suffers, more or less, from every inclemency; but it is to be hoped that by being sown generation after generation in our climate, it will eventually become stronger and more robust. This kind of barley occupies but a very short period in its vegetation; in nine or ten weeks' space it comes out of the sack as seed, and returns to it again as new grain; on this account it is frequently not sown until the middle of June. If the weather which then succeeds is warm and properly moist, the crop may turn out better even than large barley, which, from the length of time it takes in vegetating, seldom meets with a constantly favorable state of temperature. But, notwithstanding the most favorable appearances, small barley frequently does not turn out well, especially if there is any lack of humidity at the period when the ear is beginning to be developed; on an average it cannot be said to yield as good an amount of produce as large barley.

In the triennial rotation in which a very imperfect fallow only is bestowed on the autumnal corn,

and where the preparation of the fields is not commenced until July, this barley presents the great advantage of not requiring to be sown early; in cases of necessity, even the end of June may not be too late. Thus, in favorable seasons it admits of the land being half fallowed, by which means the soil is pulverized and aerated, and the weeds destroyed; this is often much more beneficial to the land than a late fallow.

The proper period for cutting must be carefully watched and embraced; the plants must not be suffered to attain to absolute maturity, especially the later shoots; because the ears, being supported by very thin and brittle stems, snap off and fall to the ground. When the grain ceases to be milky, but may be compressed between the fingers like wax, and most of the ears are of a yellow color, the period has arrived for cutting.

If there is then any danger of the grain being shed, it should be mown while the dew is on, and got in with every precaution.

This barley weighs less, and yields much less farina, than large barley. A bushel seldom weighs more than from 56 to 64 lbs. Its price is low, not only because its intrinsic value is inferior to that of large barley, but also because brewers are more accustomed to the latter, and prefer it. Small barley cannot be mixed with the large and used for making beer, because they do not both germinate at the same time; therefore it is in little request, and at present is hardly used for anything but feeding horses. Its straw appears, even in weight, to be less abundant than that of any other grain.

Two-rowed, long-eared, or large flat Barley.

Many farmers consider that this kind only thrives on clayey soils, but I have often cultivated it on land containing more than sixty-two parts in a hundred of sand, and usually with greater success than small barley, provided that I got it into the ground about the end of March or the beginning of April, with previously plowing the land, but contenting myself with burying it by means of an extirpator, in land which had been tilled to a considerable depth and thoroughly impregnated with humus, for a weeded crop. Where these conditions have been carefully observed, I have never known the crops entirely to fail; and the smallest quantity which I have obtained in these cases has been six bushels per acre, and that in the summers of 1809 and 1810, when barley suffered so much from drouth, especially about the period of the formation of the ear. I have occasionally obtained as much as fifteen bushels per acre from a soil thus tilled and prepared: but then it was in excellent condition, and the season was highly favorable to it. Consequently, I decidedly prefer large to small barley in any rotation which is adapted to this grain.

Large barley, when sown early, suffers but little from frost; and even when the tips of the leaves turn yellow, it has not sustained any great injury. When sown on a sandy soil, the leaves will often assume a yellow tinge during dry weather, but the plants are not the worse; all that is required is a little moisture at the period when the ears are beginning to form, this being the most critical period. But if the plants turn yellow from excess of moisture, which is too often the case in low, damp situations, they will inevitably perish.

In large agricultural undertakings, where it has been sown pretty early, one thing attending it is very inconvenient; namely, that it ripens about the same time as the rye; and although it is less apt to shed its grain than small barley, the laborers must be taken off the rye in order immediately to cut it. This circumstance may be an inducement to sow it later in the spring, and, on clayey soils, even as late as the beginning of May; and to sow small barley on the sandy soils. When large barley is ripe a bushel of it will weigh 70 and odd pounds.

Siberian, or quadrangular naked Barley.

Botanists regard this as a variety of the *hordeum vulgare*, or small quadrangular barley, and believe that it always retains a disposition to resume its original form. I have my doubts on this point, although now and then some of the grains strongly resemble those of small barley; these, however, are such as have not attained their full growth, cannot separate themselves from their valves, and either do not germinate and appear above ground at all, or else produce Siberian barley. But as it frequently is almost impossible to distinguish between our cultivated species, we cannot come to any determination on the point.

Siberian is distinguished from small barley by its plants being fuller, more bushy, and putting forth more blades, even when both kinds are grown on the same soil, and the plants sown at equal distances from each other. The stems which bear the ears are much thicker than those of large barley. The ear is longer than that of small barley, and contains a greater number of grains; but the most distinguishing characteristic is, that when the ear ripens, the beard falls off, and the grains separate themselves from the valves, and assume a different form from that of other kinds of barley. Where the soil is rich, the ears of this barley are usually six-rowed.

From its grain being naked, and having an appearance different to that of barley in general, it has been called wheat, rye, barley-wheat, &c.; and also David's corn, Jerusalem corn, and Egyptian or Wallachian corn. Gaspard Bauchin termed this kind of barley *zeopyron* or *tritico speltum*.

As Siberian barley has long been known to both agriculturists and botanists, it seems at first sight strange that it should not be more generally cultivated on fertile soils. Nevertheless, when we come to consider what are the conditions requisite to ensure its success, we cease to wonder that should not be so. It unites in itself all that can render spring corn recommendable. It is strong; its produce is certain; it grows thickly; the stem which bears the ear is stiff, it yields a considerable quantity of nutritious grain; its straw is excellent, and fully equal to that of wheat straw; and, upon the whole, it is much more productive than large barley. But it requires a fertile, rich and well-tilled soil; and as my friends have always cultivated it after their fallow crops, I cannot say whether, if sown on the stubble of some other grain, would yield so much better than all other kinds of barley, which it certainly does in the cases I have named. It must also be got into the ground as early as possible, in order to allow it time to come up, and put forth its leaves and stems

before the warmth of the weather induces the formation of the ear. Several persons who have sown it late have seen their crops fail. If attacked by frost while young, it suffers very much. It is said that when sown early, like autumnal corn, it has been cut several times in the course of the summer; and on the succeeding year has yielded a good crop. But this account is, in all probability, exaggerated; at any rate, we cannot give credence to it until it has been confirmed by well attested experiments.

This barley is usually of about the same weight as rye; sometimes a little heavier.

With regard to its nutritious properties, Einhoff found that they amounted to 74¾ in a hundred parts, being thus 2¾ more than rye. But he observes that it has so large a proportion of sweet mucilage and of vegeto-animal substances, and consequently of the most nutritive matters, that it ought to rank between wheat and rye. ("Annalen des Ackerbaues," b. viii. sec. 27). By adding a little wheat and a little rye to it, a highly nutritious bread may be made.

Several experiments made by brewers with this species of barley have failed, the beer being strong, but thick and muddy, while others, on the contrary, have succeeded in producing very excellent beer. It is very much prized by brandy distillers. This grain is fully equal in value to rye.

Naked flat Barley.

This kind somewhat resembles the preceding in many respects; but the ears are longer, and it is only two-rowed. When individual plants are cultivated in good garden ground, it yields a larger grain than that of Siberian barley; but decreases in size very materially when a crop is sown in the open field. In all those experiments or trials of it of which I have heard, it yields a much smaller amount of produce than Siberian barley. In speaking thus, I do not, of course, include those experiments made in gardens with a view to ascertain to what extent one grain may be multiplied. This barley is one of the numerous descriptions of grain which I abandoned after having given them a fair trial.

Six-rowed, or Winter Barley.

This is admitted by botanists to be a distinct species, but in my opinion it is not only a variety of the quadrangular barley; although, in its natural state, it has a distinguishing characteristic. Quadrangular barley is likewise six-rowed; but in that the grains stand out more when they ripen, and thus form a hexagon. But I believe this to arise solely from some difference in the mode of cultivation, and regard it as more probable that this species has been created by some insensible metamorphosis which has taken place in the *hordeum vulgare;* which ceases to be so delicate when sown early, and may very likely, in the course of several generations, become able to bear the severity of winter, and gradually assume the form of the kind we are now speaking off.

Six-rowed barley, habituated to being sown as autumnal grain, requires a rich yet consistent soil; such a one as would be proper for wheat. In low situations, where the soil is fertile, it is preferred to all other kinds of barley, especially on those lands on which wheat would be liable to be laid; and it is chiefly on this account that it is so much cultivated. It is rarely laid, and sometimes yields an enormous amount of produce—often as much as twenty-eight bushels of grain per acre, and never less than twenty-two. It occasionally suffers from the severity of winter, and where this is the case, it seldom or never recovers itself. In such cases, therefore, the best way is to break up the ground at once, and sow it with spring barley. On poor, or even on mediocre land, six-rowed barley never thrives; it requires a soil such as would be considered as proper for wheat.

This barley should be sown as early as August, if we would have it capable of resisting the winter, and on a fallow, or some preparatory crop which has thoroughly loosened the soil. Cabbage or rape is usually considered as the best preparation. It then ripens in good time, either about the end of June or the beginning of July; and this circumstance is a great recommendation to it, as thus the labors of harvest are more divided; besides, at this time barley is often in great request. It is threshed immediately after being reaped, and sent to market. Under these considerations, it offers many very great advantages; but apart from them it finds few advocates, its grain being even more diminutive than that of small barley, and in general lighter, and it being altogether an inferior crop.

Sprat, Battledore, or Rice Barley.

This species is also known by the names of bearded barley, peacock barley, German rice, fan barley, Venetian barley, and Japanese barley. It has long been known, and was formerly much more cultivated in Germany than it now is.

Its ears are shaped like a lancet; they have two rows of strong beards or awns, which diverge from the stem to which the grains are attached.

It grows very bushy, and consequently, ought to be evenly sown, and treated in all respects like large flat barley.

I have made various trials of it, but cannot discover that it is in any way superior to large barley, excepting that its stem, being short and strong, it is never laid, even when sown on the richest land. But I prefer sowing Siberian barley on good land. I cannot say that I have ever perceived in what manner its grain can be said to resemble rice.

OATS (AVENA SATIVA.)

Under this botanical term is comprehended a portion of those varieties of this kind of grain which we know and cultivate. To this species belong:

1. *The common white or March oat,* which is most generally cultivated, and most to be depended upon when sown in a soil adapted to it.

2. *The heavy oat,* called by us the "English oat,' and by them the "Polish" or "Spanish oat." It is distinguished by its stiff leaves and stems, large panicles, and equally large grains; at least when grown on a soil suitable to it. When sown in damp, marshy land, the ear becomes even

larger; but then the husk thickens. and the grain acquires little or no additional weight. It is said that it may be cultivated as autumnal grain; but I am not aware that this assertion is borne out by any recorded facts.

3. That *oat* distinguished by naturalists as a particular species, under the name of the *avena trisperma*. which sometimes contains three ripe grains in one husk, but which, for all that, does not appear to yield very large amounts of produce.

4. *The early oat*, which may be sown very soon, and ripens early in the year. This species is chiefly valued in mountainous countries, where all other oats would not ripen before September.

To the black grained oats belong:

5. *The black glossy oat*, the grain of which often weighs ten pounds per bushel more than any other kind, and is, consequently, infinitely more nutritious. It requires a rich soil, and is peculiarly adapted for low situations, while on elevated grounds it is easily laid or blown down by high winds.

6. *The acorn oat*, the grains of which are partly white and partly black, and which is, consequently, both a variety and a mixture of the white and black oat. It has a very hard husk, but a very farinaceous grain.

We have a distinct kind of oats, and one which has, consequently, been regarded by botanists as a peculiar species, in the—

7. *Georgian, Turkey, or Hungarian oat*. It has a long compact panicle, and its grains turn mostly toward one side. When first introduced, it was said to yield a very large amount of produce; but subsequent experience has served to prove that it yields neither more nor less than common oats. It ripens later, and is not so liable to shed its grain; and probably it is on this account that farmers who sow a great quantity of oats, continue to grow this on some portion of their land. Its great defect is, that it cannot be threshed without difficulty.

8. *The hairy oat*. I shall not venture to decide whether or not this is the *avena strigosa* of botanists, which they state grows wild with us. General experience has, however, proved that common oats will reproduce themselves on a sandy soil, especially in heathy or furzy districts, and become transformed into this variety—not immediately, it must be confessed, but by degrees; and that they will resume their primitive form on being sown in good ground. Does the same effect result from this as is produced by the growth of hair-grass among autumnal corn, viz: that the wild plant being best adapted to the nature of the soil, establishes itself and chokes or destroys whatever grain is sown? Or does one species actually assume the form of another; and is it, therefore, only a variety? This hairy oat has several strong awns which do not fall off: a thick husk, and but little farina. It hardly weighs half as much as common oats; nevertheless, on these poor soils it is not without its advantages. When sown on a richer soil, it puts forth strong stems and a large leaf, and is then cultivated as fodder, and mown while green.

9. *The naked oat (avena nuda.)* This kind is but little introduced among us; in Scotland it is much cultivated, and made into bread.

The English recognize various other kinds of oats, but they are only varieties obtained by cultivation.

For some time past, oats have been treated among us as one of the worst and poorest of all the cereal tribe, and, consequently, have only been sown on the worst and poorest portions of land. Formerly, the price of this grain was less than half that of rye; but since a greater number of horses have been kept, its price has risen above that which it bears relatively to other grain, in consequence of its being so eminently adapted for the feeding of these animals, and hence its cultivation has become more profitable. Nevertheless, it is seldom grown even now, excepting in places where it is not deemed advisable to sow any other kind of grain.

The soil for oats may be of any kind whatever, provided it be sufficiently but not too dry; this grain has such vigorous organs that they can dissolve and appropriate nutritious particles which would be of no use to any other kind of corn. They even appear capable of dissolving insoluble acid humus. It will grow on the most tenacious, cold, or clayey soils, as well as on poor gravelly land where nothing else will vegetate. It suffers from unfavorable and inclement weather, but recovers itself much sooner than barley when the weather begins to improve. On newly broken-up land, or on marshy ground, it may be cultivated for several consecutive years, and its produce will often go on increasing until the third or fourth year; while a crop of any other grain would exhaust the soil at once, if it is not immediately ameliorated. The reason of this probably is that oats appropriate to their nourishment every particle which the soil will yield, and which would not be dissolved by other plants without the aid of time and tillage. Oats when cultivated on a fertile soil, are, however, much more profitable.

In the triennial rotation with a fallow, this grain is cultivated as the fourth or sixth crop, and generally in places where barley would be unable to find any nourishment. It would appear that, on strong wheat land, it is always better to cultivate oats than barley. In the Mecklenberg rotations with pasturage, oats come after barley, and constitute the last crop. The Holstein agriculturists have assigned a better situation to it, by sowing it on broken-up grass land which has been in repose; and they adhere to this plan of proceeding even when, in the ensuing winter, they intend to fallow the ground; for, on broken-up turf or grass land, where the herbage is not decomposed, oats always succeed well, particularly if sown in good time. This kind of grain is also well adapted for being sown on two-year-old clover, from which the farmer wishes to derive all the benefit he can until autumn. When such land is broken up early in the autumn, and sown with oats in the beginning of spring, covered by harrowing, and then harrowed again when the plants are just above the ground—a kind of cultivation which this grain will bear better than any other—a larger amount of produce will usually be obtained than would have been if the clover had been broken up directly after the first cutting, and the ground plowed three times, and then sown with autumnal corn.

When oats are sown on the stubble of any other grain, the land must be plowed once, twice, or thrice. Most agriculturists agree that oats sown on thrice-plowed land succeed best, but it is

seldom that they do plow land three times for this grain: this arises either from want of time, or from the crop being thought not worth the trouble. They are also deterred by a fear lest the sowings should not be performed early enough— a point which is seldom of much consequence, unless the climate is particularly cold. Where oats are sown on two plowings, an abundance of weeds spring up; and where the soil has previously been infested by weeds propagated by their seeds, I have often found those crops of oats which are sown on two plowings more scanty than those which are sown on one only. But where, on the other hand, the field has been chiefly infested by weeds propagated by their roots, the crop always succeeds decidedly better after several plowings. Land is seldom manured for oats, although, now and then, it does happen to be so, and this most frequently when the crop is to be succeeded by autumnal corn. Fresh manure agrees with oats very well, and the greater part of such an amelioration will be left in the soil for the next crop.

Oats are usually sown more thickly than any other kind of grain, either because the bushel contains fewer grains, or because oats do not grow so bushy as other kinds of corn, excepting on very rich soils. One-half more seed than would be considered as the proper quantity for any other kind of grain must be sown in this case; and on broken-up grass land, which has only had one plowing, the quantity had better be doubled, because all the seeds do not come up. There are, however, some places in which they increase the quantity of seed sown on grass land to an extraordinary extent, in the hope of thus destroying the weeds.

To ensure the success of a crop of oats, it is necessary that the seed should be plump, fresh, and uninjured by fermentation. Oats which have acquired an unpleasant taste or smell while in the sack or store-house, certainly come up from the ground like others; but they produce a weakly plant, which perishes at the flowering season. I accidentally obtained proofs of this during the period that I was studying Agriculture. There is no grain besides wheat, in which this evil requires to be guarded against so much as in oats.

The usual period for sowing oats is in April: on broken-up pasture land they are sown in the middle of March, if possible; but where the situation is warm, the sowing may be delayed as late as the commencement of June: and it is when thus sown that oats succeed best, provided that the weather is favorable: this is occasioned as much by the soil having received a better preparation, as it is by the destruction of the weeds being more complete.

Oats do not germinate so easily as barley; nor is the process of germination so uniform, excepting where it takes place under a very favorable temperature. The crop does not come up simultaneously, nor do the plants ripen equally. Many weeds which germinate with oats, as for instance the wild mustard and the wild radish, tend materially to weaken the crop; and should, therefore, be destroyed by harrowing. Oats bear this operation very well, even after the plants have begun to appear above ground, especially when they have been sown in rows, covered by a light plowing, and the soil then superficially harrowed. When a period of favorable weather has supervened, and the weeds have only put forth their seminal leaves, the operation of harrowing will be productive of very great benefit; but when the third leaves are developed, and the weeds have taken deep root, it does little or no good; for if it were carried to a sufficient depth to ensure the destruction of the weeds, it would inevitably injure the oats; consequently many persons have endeavored to delay burying the oats sown on plowed land, until they have put forth germs of at least an inch and a-half in length, in order that the crop may shoot up rapidly, and free from weeds. This plan has proved successful with many, their oats having come up exceedingly bushy, and free from weeds; but with me it did not succeed at all, my oats seldom appeared above the ground, and an immense quantity of weeds choked the soil. The third and last trial which I made of it was attended with rather better success, for the seed did come up; but a period of dry weather succeeded, which prevented it from thriving as it ought to have done.

Great attention must be paid to the ripening of oats; and where they ripen unequally, the cutting must be commenced the moment that the first part is ripe, or the grain will most likely be shed; besides, if the remainder does not come to maturity, and the grain cannot be separated from it by threshing, it will but serve to increase the value of the straw, and render it more nourishing. Moreover, the grain which ripens first is always most substantial. When oats have been cut before they are completely ripe, they must be allowed to remain in the swaths for a longer period; and some persons believe that they then ripen and increase in weight: the actual fact is, that they will be very liable to decrease and spoil if left too long.

Oat straw is more esteemed for provender than that of any other grain, perhaps because there usually is more grain left attached to it than to any other kind of straw. In many farms this grain is purposely left, and the oats are but slightly threshed. When used as litter, and thus converted into manure, it is only regarded as beneficial to warm soils.

As oats weigh very light (not more than fifty pounds per bushel) and, according to analysis made by Einhoff (a superficial one it must be confessed), do not contain more than sixty parts in hundred of nutriment, consequently only thirty pounds in a bushel, this grain is not equal to half the value of rye. But I am inclined to think that Einhoff founded this analysis on observations made on bad oats, and that this grain is worth at least half the value of rye. In many countries it fetches a higher price, on account of its being so much esteemed as fodder for horses; while in others which are far better adapted for its cultivation, but where there is less sale for it, its price falls below one-half the price of rye.

MILLET (PANICUM).

Millium femine-luteo of Tournefort, *Paniculum milliaceum* of Linnæus.

This plant undoubtedly belongs to the cereal tribe.

There are two kinds of it cultivated: The common millet (*Panicum milliaceum*), and the German millet (*panicum Italicum* or *Germanicum*). There are several varieties of each of these which are chiefly distinguished from one another by the color of their grain. The common millet is preferred as having the largest grain; and the German millet as being least liable to shed its grain, as ripening more quickly, and as not being so much robbed by birds. The cultivation required by both is the same or nearly so.

Millet requires a warm, rich, sandy, well pulverized soil. It succeeds better when sown after some crop which has been abundantly manured, than it does when sown immediately after an amelioration of undecomposed manure.

A soil must be tilled to a great depth for its reception, and plowed three times, besides being harrowed, rolled, and thoroughly freed from weeds. Many farmers dig their ground to a great depth previously to sowing it with this plant; but a good plowing answers the purpose equally well. Millet is in general very successful on newly drained land, provided that it is in good condition, and also land which has been left in repose for several years; in the latter case a single plowing is sufficient, if the soil is subsequently harrowed, and well broken up with a roller, before the seed is put into it. When this class of soils are too dry for linseed, there is no more profitable means of employing them than by sowing them with millet.

Millet should be sown in May; about three metzen of seed is the quantity usually used per acre; a harrow is then passed lightly over the soil, and where the ground is dry, a roller must also be used. The seed must be thoroughly ripe, perfect, and free from disease.

As soon as weeds make their appearance among millet which is just shooting above ground, they must be eradicated by weeding. This is absolutely necessary, if we would not endanger the success of the crop; and can only be dispensed with where the land has only lately been drained, and brought into cultivation, and consequently, has few or no indigenous weeds. It is on this account that millet can seldom be cultivated to any great extent. One weeding is rarely sufficient for it; for, if the soil is at all disposed to produce weeds, it will require a second, if not a third; each one following about a fortnight or three weeks after the other.

The best way is to tear up the weeds with hand rakes constructed for the purpose; this mode of proceeding answers far better than hand-weeding, as by its means not only all the weeds may be eradicated. but the supernumerary plants may be thinned off. The effect of this cultivation on the success and vegetation of the crop is wonderful; after it the millet shoots up so rapidly that the weeds seldom have time to grow again, or, if they do, it is in very small numbers, and they may easily be pulled up.

Great attention is requisite to seize on the exact moment at which the plant attains maturity, especially with common millet, which ripens very unequally, and is very liable to shed its seed. This evil is, however, much less to feared where the crop has been cultivated, and thinned in the way we have mentioned. Those who only cultivate millet in patches, cut off the spikes as they ripen, and carry them home in sacks; but as this can only be done where this plant is cultivated but little, the reaping must be commenced as soon as the greater part of the plants are ripe, and performed with great care with a sickle.

This plant must not be left on the ground in swaths, because if rain comes on, and it gets wetted, it sheds its grain. It should, on the contrary, be immediately carried to the barns, and there threshed, and freed from all impurities and foreign substances as much as possible. The grain should then be spread in very thin layers over the floor, and stirred about every day with a rake until perfectly dry, otherwise it will become heated and bitter. The straw is tied up even though moist, and carried into the air to be dried; if not properly dried, it will become mouldy on being stacked. This straw is much esteemed as provender for cattle.

Although when cultivated to any great extent, it is not possible to cut off the ears separately as they ripen, it is worth while to gather all those in this manner which will be required for seed. Grain which ripens thoroughly, and of which proper care has been taken, shoots up evenly, and produces perfect plants, free from disease, and especially from smut, which frequently manifests itself in this grain where proper precautions have not been taken. That portion of millet which is intended for seed should be preserved in some place through which there is a free circulation of air, and where it can become perfectly dry: it should be threshed when wanted. The best way of freeing millet from its husk is by making use of mills somewhat resembling fulling mills, which beat it with sticks or hammers.

Millet is well known to be a very nutritious grain; in most countries it forms an article of food, and in many cases is used instead of rice. Consequently, its price generally bears a relative proportion to that of rice.

Millet is also cultivated as fodder; it is then sown more thickly, and mown as soon as its panicles are developed.

That plant which is designated under the name of marsh millet, belongs to another species or family of vegetables. One variety of it ripens with us during warm summers, and when sown in gardens; it is called Indian millet *(holcus sorgham)*. There are several other kinds, but they all require warmer climates; and it is far from probable that any of them will ever be naturalized in our country, therefore I do not consider it necessary to particularize them.

Rice, and all the varieties of that family, are also by no means adapted to our climate. although in many of the records of different agricultural societies accounts of, and instructions respecting, its cultivation are to be found. I question much if it will ever ripen in the north of Germany, unless it be in hot-houses; even in the south of France, several experiments made with a view of introducing it have been unsuccessful. The nearest place where it can be raised is beyond the Alps. I am well acquainted with one case, in which the parties thought they had sown and raised rice, and it turned out to be Siberian barley.

Lastly, from its nature, maize should be included among the grain tribe; but as its cultivation differs *in toto* from that of those we have already mentioned, and closely resembles that appertaining to weeded crops, we shall defer an account of it until we come to treat of that portion of our subject.

THE CULTIVATION OF GRAIN IN ROWS OR WITH THE HORSE-HOE.

This kind of cultivation is equally applied to all other kinds of crops; but as it appears peculiarly adapted to grain, I shall speak of it here.

We find instances of its being known and practiced as far back as the 16th century. Joseph

Locatelli, a Spaniard, made some experiments in it which drew upon him the attention of the Emperor, and caused him to be summoned to repeat them in the presence of the monarch. But what appears still more extraordinary is, that it was known in Persia and Hindostan; that the rows were there sown by proper machines, and the plants cultivated during their vegetation with instruments worked by horses or oxen. In England, Jethro Tull is regarded as the inventor of it. In France, Du Hamel, Chateauvieux, and others introduced and propagated it about the beginning of the 18th century. But Tull's mode of proceeding, according to which very broad spaces are left between the rows, which are repeatedly tilled with a plow during the vegetation of the crop, is nearly out of date, and has given place to another in which the rows are parallel with, and nearer to each other. We shall content ourselves here with speaking of the latter, and refer our readers for details of the former to the 1st and 3d vols. of our "English Agriculture." Persons who take an interest in the matter will, probably, have already read those dissertations, and will here find some contradictions of what was then stated; but we must beg them to consider, that the statements which are about to be made, are the result of more mature experience, and founded on numerous experiments.

The machines for sowing corn in rows, and the horse-hoes which have been invented in England, are too numerous to admit of their being severally described. Almost all agriculturists agree that Cooke's sowing machine is the best; but it is very complicated, and must be used with great care. In the first part of my "Description of the Agricultural Instruments in most general use," I have given a plate of *Ducket's* machine for sowing corn in rows; and, in the third part of the same work, that of another invented by myself, with proper descriptions. Long experience has convinced me that the latter is so convenient, durable, and easily used, and answers my purpose so well that I could not desire a better; although I can only sow corn, peas, vetches, and lentils with it, and not any of the smaller seeds which Cooke's machine will sow. Neither can I regulate or alter at will the quantity of the seed of each kind of grain which it shall sow; but it always distributes a quantity which is amply sufficient for every case or exigency; and although it is true that occasionally something might be saved out of this, the saving would be so trifling that it is scarcely worth mentioning. It only uses half the quantity of seed in sowing wheat, rye, and oats, which would be required if the broadcast or hand sowing were put in practice. This machine suits all kinds of land; it can be used on the stiffest clays without receiving any injury, jolt, dislocation, or fracture, and therefore may be trusted even with inexperienced or careless laborers. Its frame also serves for the horse-hoe; all that is required to be done is, to detach the seed-box and substitute for it some implement of the hoe, coulter, or pronged kind, which will best fulfil the end in view. There is not the slightest difficulty in using this instrument, but it is impossible to give an intelligible and useful verbal description of the manner in which it is used.

This kind of cultivation may be bestowed on land of every descripion, from the most tenacious to the most friable, provided that it has previously been properly tilled. Nevertheless, when it has to be applied to clayey soils, the moment must be seized when they have attained that degree of moisture which best befits them for receiving the various kinds of hoe tillage.

When the soil is very sandy in its nature, those marked advantages so often attendant upon horse-hoe tillage must not be expected. Land containing from 30 to 60 parts in a hundred of clay is best adapted for and best repays this kind of cultivation.

A field may be on a declivity, in which case, the share or six-pronged hoe, which forms a portion of this instrument, does not enter equally into the ground. The soil must be rich and well cultivated to enable this operation to be productive of its full advantages. Poor land will be incapable of feeding that vigorous growth of stems and leaves which is induced by the action of the hoe. When the temperature has been favorable, a considerable increase of produce has often been obtained even on poor soils by sowing the corn in rows, but the proportional increase here was nothing to what it would have been on rich land; and, in many cases, the ears which the plants bore had not sufficient nutriment to enable them to form their grain.

The soil must be completely free from those large stones which come up into the layer of vegetable mould, as the share and prongs of the hoe would inevitably be broken if they came in contact with them. Small stones do not altogether impede the operation of sowing in rows, but they wear out the implements very much; it ought, in fact, to be laid down as a general rule, that this operation should never be introduced until those stones which are capable of doing harm have all been removed.

Another indispensable condition to the success of this mode of cultivation is, that the land shall be entirely free from those weeds which are propagated by their roots, as well as from all others which perpetuate themselves in the soil; and also that it shall be, as far as possible, free from those which are propagated through the medium of their seeds; for, though many of these weeds are destroyed, and others prevented from coming up by the use of the horse-hoe, they are not completely eradicated. Supposing the horse-hoes entirely to destroy those weeds which come up in the spaces between the rows, they cannot touch those which spring up in the rows and among the corn. The weeds impede the passage of the shares or irons of the hoe, and cause them to drag portions of earth along with them; a part of the weeds certainly are torn up, but those which grow in the rows are only rendered more vigorous, and enabled to shed their seed on ground loosened and prepared for its reception by tillage. Hence it results that this kind of cultivation seldom succeeds in cleansing a soil from weeds which is infested with them; but it will keep a field clear which is from the beginning tolerably free from weeds, provided that pains are taken to detect and pull up every one that makes its appearance among the plants in the rows, which will be a comparatively easy task, for but few will be found.

This system of cultivation admits of the possibility of the ordinary rules for alternating the crops being neglected, which no other can do, and of several crops of corn being raised successively, on account of its tendency to keep the soil loose and clear. A field which has been drilled and properly cultivated with a horse-hoe will generally be found to be so thoroughly loosened and pulverised after the first plowing as to be fit for the reception of seed without any farther preparation.—

Those persons, therefore, are quite wrong who assert that drill-sowing is intimately connected with alternate rotations; on the contrary, it supersedes the necessity of them, and strict adherence to them renders it almost impossible to drill all the crops: this is one of the principal objections alleged against them by Arthur Young and other English agriculturists. If clover is to be sown on barley which succeeds to a weeded crop, this can only be done where the preparatory tillage has been perfectly performed; the seed must be got into the ground as soon as the hoe has been passed over it for the last time, in order that it may come in contact with a layer of fresh earth. This seed falls into the furrows drawn by the feet of the hoe, and when the weather is favorable, comes up in rows, and yields a fine crop; but sad experience testifies that when the weather is unfavorable it is often completely destroyed. Once, a heavy shower came on directly after I had thus sown my clover, which washed all the loosened earth into the furrows, and wedged the seeds down so tightly that the young shoots could not make their way up, and consequently perished.—At another time, in 1810, a long period of drouth supervening on the sowings prevented the clover from germinating at all, or else dried it up as soon as it began to sprout. Such late sowings in which the seed cannot be brought into contact with the interior of the soil are always prejudicial to the success of the crop; so much so, indeed, that I have resolved never again to drill barley, when it is my intention to sow clover on it. Autumnal corn may be sown in rows on a single plowing, provided that that operation has been carefully performed, and the soil has settled down sufficiently; but the roots of the clover impede the action of the machine, and prevent the drilling from being so easily accomplished as it otherwise would have been. On the whole, this kind of tillage keeps land very loose and clear, and causes it to yield crops which, even when sown consecutively, are not nearly so inferior to those which, in the alternate rotations, only occur at certain intervals, as successive crops of grain sown by broadcast and not cultivated with the horse-hoe would be. In fact, this system of tillage may be said, in a great measure, to supersede fallows and weeding.

The advantages of drill sowing may be summed up in this, that by its means the grain can always be placed in the ground at the exact depth required by its nature, by the nature of the soil, and the state of the temperature; and, consequently, every healthy seed is sure to germinate. But this advantage does not, perhaps, surpass the injury resulting from the accumulation of the seed in the rows; hence it becomes evident that it is the hoe tillage which gives to drill sowing such an incontestable advantage over broadcast sowing, an advantage which has been demonstrated by countless comparative experiments. Every one is well aware that a highly beneficial effect is produced on the vegetation of plants by the loosening of that crust which is formed over the surface of the soil. Hitherto, however, it has been chiefly noticed in garden ground, for very few persons have undertaken experiments on a large scale for the purpose of testing it. This practice is especially beneficial when, in the spring, the hard crust which had been forming all the winter is opened and broken, and the soil thus brought into contact with the atmosphere; and it is on this account that hoe tillage is so much more beneficial when applied to autumnal corn, than it is when applied to spring corn, and especially to such as, like quadrangular barley, vegetates in so short a time that the ground cannot harden sufficiently to impede its growth. It is, however, on wheat that its beneficial effects are generally most evident, either on account of the duration of the vegetation of that grain, or else because wheat requires more nutrition than any other kind of grain, and the action of the hoe brings the nutritive particles of the soil within the reach of its roots. Besides, great benefit arises from that accumulation and heaping of fresh earth round the stems of the plants, which hoe-tillage effects. This tillage is exceedingly beneficial to all plants, but especially to those which, like cereals, put forth roots from their lower joints, and which roots thus find themselves surrounded with fresh earth. It should be bestowed on the crop when the plants are most in want of nourishment, at the period of their active vegetation, and when the ears begin to show themselves.

It has sometimes been observed that cereals which have been carefully cultivated with a horse-hoe remain longer in the ground, and flower and ripen much later than others. This is not, however, always the case, although I have very frequently remarked it; where it does happen, it will always be favorable to the crop, since the plants then grow more bushy, and, late in the season, put forth a larger number of blades at once. When grain is sown in drills, a greater degree of equality will always be observable between the blades and ears, than is ever seen when the crop is sown by broadcast; and those late and abortive ears which are so often found in crops sown in the last named manner are rarely seen. This kind of tillage gives a greater degree of strength to the bottoms of the stems than any other, and that is one reason that grain sown in rows always stands erect in cases where otherwise it would be laid, a circumstance which is alone sufficient to render it highly advantageous.

Many persons, while they acknowledge the beneficial effects of horse-hoe tillage on damp, tenacious soils, fear to apply it to loose, dry, gravelly land, lest it should tend to render it still more arid; but, on attentive examination, this fear will be found groundless. Land which is kept loose on the surface will retain moisture for a much longer period during the summer, than land which is covered with a hard crust, because during the night the former will attract moisture from the atmosphere. Light rains moisten loose ground much more than they do that which is close, because, in the former the moisture can penetrate into the soil, whereas in the latter it remains on the surface, and is quickly evaporated.

For some time past there has been very great difference of opinion with regard to the distance apart which the rows ought to be. Some farmers consider six inches to be the proper distance, others twelve; but at present it pretty generally admitted that from eight to nine inches is the distance most suitable to all kinds of grain. Where the space between the rows is less than this, it can hardly be perceived that the earth has been hoed up round the stems of the plants, the instrument takes up so little earth; while, on the other hand, a wider space is useless, and only wastes the ground. The best way is, in spring corn, to drill the rows as close together as possible, and in autumnal corn to set them farther apart. In order to effect this, an alteration must be

made in the machine used for drilling; mine drills the rows at about eight inches and a half asunder, and I consider that to be a very good distance.

Next to the grain crops, vegetables profit most by being sown in rows; and this system certainly has a very advantageous effect upon them. I have, however, found it attended with some inconvenience as regards peas; when I have sown them in this manner, I have been only able to cultivate them with the hoe while very young, and then the earth could not be heaped round them for fear of smothering them. As they became older, their stalks spread out so on all sides that the horse-hoe could not be brought near them for fear of tearing them. Notwithstanding the utmost vigilance, I have never been able to seize on the proper period for hoeing this crop with advantage. When I sowed my peas farther apart, they did not cover the soil sufficiently, and yielded better, certainly, but much less straw than when sown by broadcast. I will not, however, pretend to deny that these inconveniences might be obviated at that time, and then it would become exceedingly advantageous to drill and hoe peas.

On the other hand, drill-sowing is peculiarly adapted to lentils; these plants should be sown at the same distance apart as peas; the smaller ones with the barley, and the larger ones with the oat-cylinder. Lentils thus sown usually bear an extraordinary number of pods, and may, without much trouble, be kept free from weeds.

That which is said respecting the expense of this kind of cultivation will be found, by those who are at all acquainted with it, to be entirely without foundation. Even when the increased expenses of the operation are valued at the highest possible sum, and the cost and keeping in order of the machine also taken into account, these sums will be more than defrayed by the saving in the seed. In order to obtain an approximative, and, at the same time a sufficiently high estimate of these expenses, I will suppose that only two acres of land can be drilled per day, and the same extent hoed. I shall reckon the horse labor at twelve groschen per day, and the work of the two laborers at the same; consequently a day's work will cost one rix-dollar. The sowing machine is passed over the ground once and the hoe twice; which will make the sowing of ten acres cost three rix-dollars, or that of a hundred acres thirty rix-dollars. If on one hundred acres of land I sow nine metzen of seed on each one instead of eighteen, I shall save nine hundred metzen, or fifty-six bushels and a half of seed; and if I reckon each bushel to be worth one rix-dollar, in order to have round numbers, I shall save twenty-six rix-dollars and a quarter. In order to be able to sow one hundred acres of autumnal corn in ten days, I shall require a machine with which I can sow and cultivate a similar extent of spring corn; such an one, with all its fittings up, may be obtained for one hundred and fifty rix-dollars. To this sum I shall add 4 per cent. interest, besides a diminution of capital of one-sixth per annum; consequently, in six years there will be one hundred and eighty-six dollars. On the seventh year it will be paid for by the saving it has effected in the seed. Such a machine will certainly last twenty years, especially if only used for autumnal corn. Every three or four years it will require repairs, but the saving in seed will be amply sufficient to cover these, and some left to allow of the hoes being newly ironed or footed if requisite.

Should it be necessary, as some persons pretend that it is, to keep an extra horse solely for the performance of this operation, then drill sowing will undoubtedly become expensive; but there are very few farms in which this will be requisite.

Besides, the advantages arising from drill sowing do not, as some imagine, consist solely in the saving of seed which is thus effected, but in the increased amount of produce which, under this system, the land may be made to bear. The fact of this increase is demonstrated by a thousand experiments, and no doubt can longer be entertained on the subject even by the most virulent opponents of the system. No general estimate as to the average amount of this increase can be given, as most of the comparative experiments made for the purpose of determining it have been attended with different results. In many of them the wheat thus sown yielded one-third more than that which was sown broadcast; this calculation was based on the extent of land sown, and not on the quantity of seed used: according to another experiment it only yielded one-fifth more, and according to another only one-tenth. The variation in these results was, in a great measure, created by the nature and condition of the soil. The richer, deeper, and more free from stones and weeds a soil is, the greater will be the advantages arising from drill-sowing; while on poor, shallow land, the benefits will be but trifling. Many farmers who pursue this system of sowing state that the longer they adhere to it the better their land becomes; while others, on the contrary, assert that the land deteriorates. This contradiction may easily be accounted for; there is little doubt but that the former manured the soil sufficiently to maintain its fertility, whereas the latter neglected to do so, and put their faith entirely in the beneficial effects of horse-hoe tillage; for it cannot be doubted that the soil is exhausted by the additional amount of produce which drill sowing causes it to bear, although this exhaustion is not apparent during the first few years.

The grain of cereals which are regularly sown in this manner, acquires greater perfection every time it is reproduced. All the experiments which have hitherto been made tend to prove that it is much heavier than that which has been sown broadcast. In flat barley I have found a difference of 6 lbs. per bushel, and in wheat an even greater increase of weight. The grain is large and full, which renders it peculiarly well adapted for seed. If, then, we would obtain good grain for seed, we must always keep a machine for drilling and use it.

We cannot, however, advise the adoption of drill sowing for every kind of grain, or even for all winter grain, excepting in those agricultural undertakings in which every detail is carried to the highest degree of perfection, and the whole process of cultivation followed up with science and skill. Crops sown in drills or rows require constant attention to enable the farmer to fix upon the best period and means of hoeing them. One single instance of carelessness or neglect will often seriously injure the crop; therefore, those who are not well skilled in all the manipulations of this system must proceed with the utmost circumspection, and experimentalize on a small piece of ground first, in order to learn how to manage; most persons, when first they begin to use the horse-hoe, are either too timid or too venturesome. Drill

sowing when applied to poor land does not repay the labor and trouble it occasions. Lastly, in a farm which is not properly organized, and where there must necessarily be many things which require the attention of the farmer, it is seldom prudent to enter upon this system of cultivation.

It is in the spring only that autumnal corn should be hoed: when this cultivation is applied to the crops in the autumn, it does not appear to be productive of any great benefit, let the seed have been got into the ground ever so early. The crop should be hoed as soon as the seed begins to appear, and the ground is tolerably dry. In general it will be found advantageous to pass an iron harrow across the rows first, which serves to break that hard crust which has been formed over the surface of the soil during winter; where this is not done, the feet of the hoe will be very likely to throw the earth over the young plants, and smother them. Should the soil be too tenacious to break at once, a roller must be passed over it after the harrow, provided that the ground is dry enough to admit of this operation being performed, for it is of the utmost importance that the surface should be thoroughly pulverized. The next step to be taken is to fit such irons on to the horse-hoe as will drive the soil from the middle of the spaces and heap it against the rows of plants on either side: this should be done at the period when the corn is beginning to shoot up, and put forth its stems and blades. Such cultivation will not do the crop any harm even if adopted after the plants have put forth their leaves and stems; but it should be finished before the ears begin to form. The farmer must endeavor to embrace that moment for the performance of this operation when the soil contains exactly the proper amount of moisture, and is neither too much hardened by drouth, or softened and rendered clammy by wet. It will not unfrequently happen, when the weather is unfavorable, that he will be obliged to select the spots where it will be best to commence. This is, in fact, the most critical period for drilled crops; nevertheless, where skill and activity are employed, there is little fear of any want of success. There doubtless are now and then cases in which the weather is so unfavorable that the hoeing cannot be accomplished: when such occur, no very luxuriant crop can be anticipated; but if the first parts of the operation have been properly performed, corn sown in rows will always yield a larger amount of produce than that which has been sown broadcast.

Many farmers only hoe spring corn once, and then have such irons attached to the instrument as will heap the earth round the roots of the plants; and they apply this cultivation to the crop at the period when the plants are just putting forth their blades; but the crop always thrives best when it has been cultivated with rake-like irons while very young; and such cultivation is the more advantageous when it clears away the weeds from between the rows. It must not, however, be performed so soon as to cause the tops of the plants to be covered with earth. Rakes which are intended to be passed over the land early in the season must be flat and not convex, in order that the earth may slide over them, and not be thrown to the sides.

Some agriculturists have preferred dibbling corn to sowing it in rows. Where such a plan is carried into effect, the plants not only come up in regular rows, but are at equal distances from each other in those rows, and may then be cultivated in every direction, either with instruments, or by hand. A still greater saving of seed is thus effected, and one-quarter of the amount usually employed will be found sufficient. When grain is dear, this saving will almost defray the expense of the labor; and hence it is that in years of scarcity this practice has found so many advocates. The seed is put into the ground by means of a dibble, having holes in it three or four inches apart, in each of which a few grains are placed; or, with what is still better, an instrument made on purpose, and similar to that used by gardeners for sowing peas: by means of pressure of the foot, this instrument makes twelve holes at a time. The furrows drawn by the plow serve to give a direction to the rows, and a line is drawn down the center of each of these; the ground is subsequently harrowed.

It must be evident to every one that this mode of proceeding occupies a very considerable amount of time, and, consequently, can only be applicable under certain circumstances, and to a limited extent. The small farmer who works himself, and is chiefly assisted by his own family, will be most likely to derive benefit from it. Many attempts have been made to invent instruments or machines which will perform the office of dibblers, and sow the grain at uniform distances; but it has been found impossible to carry out the plan. Various experiments have also been made on this subject in Paris, which are related at some length by the Comte François de Neufchateau, in a work entitled "L'Art de Multiplier les Grains." Paris, 1809. But this work treats only of the multiplication of the seed, and scarcely refers to the expense or extent of the sowings.

LEGUMINOUS CROPS.

The cultivation of leguminous plants or of siliquous crops (for hitherto no distinction has been made in agricultural phraseology between these two kinds of produce), is, doubtless, quite as ancient as that of cereals; for reason and experience have combined to teach mankind that it is impossible to cultivate anything more nourishing, better adapted to the animal frame, and, at the same time, which yields so plentiful a crop.

Leguminous plants contain a large quantity of what Einhoff calls "*vegeto-animal*" matter (*thierische vegetabilische substanz*). This substance bears a very great affinity to animal matter, and is quite as nutritious as gluten, as it constitutes the predominating ingredient in vegetables, and they are more nourishing than cereals. It has long been known that lentils, peas, and beans, not only satisfy hunger best, but are more easy of digestion, and have a greater tendency to strengthen the frame than any other vegetable products. To the healthy laborer they supply the place of animal food, and yield that nutriment of which rye and potatoes are incapable. With us they are absolute necessaries to those who work hard, and especially to sailors; neither landsmen nor sailors are contented unless they can have a meal of legumes at least twice a week. Both experience and chemical analysis tend to prove that legumes are the most nourishing part of the vegetable kingdom. The straw, even when exhausted, is equal to the straw of grain; but as it never is dry when mown, especially that derived from climbing vegetables, which retains its suc-

culency and vitality unimpaired up to the period of its being cut, it is generally much more nourishing than the straw of grain crops. The haulm of these vegetables, too, when cut before the formation of the fruit or seed, yields a far more nourishing fodder than any of the cereals do.

This class of leguminous plants appear not only to be particularly nourishing to men and animals, but even to supply food to vegetables. The great proportion of vegeto-animal matter which they contain, causes them in a great measure to resemble animal manure, to be very easily decomposed by putrefaction, and to enter more promptly into the composition of plants. It is on this account that from time immemorial, they have been used in Europe for the amelioration of other crops. The lupine, which on account of its bitterness cannot be otherwise employed, is the chief one of this tribe which is plowed into the ground as green manure; not only is this plant buried while green, but its seed is made use of for the purpose of dressing olive trees, after having been steeped in boiling water, in order to destroy its germinating principle. Other vegetables are likewise similarly employed.

Besides this vegeto-animal substance, leguminous plants contain starch, and a soluble mucous matter similar to that contained in the grain of cereals, but not so sweet.

The best way of preparing vegetables for food is to boil them. Their various component parts are thus brought into more intimate combination, and rendered more soluble, digestible, and agreeable to the stomach. They gain as much by this mode of proceeding as grain does by fermentation, and by being made into bread. They may themselves be made into bread, but then it has a crude, unpleasant, rancid taste. They are not unfrequently mixed with rye, or wheat flour, and then they render the bread more nourishing without altering its flavor.

There cannot be a doubt but that products which contain so much nutritive matter must deprive the soil on which they grow of a corresponding portion of its nutrition. Nevertheless, it appears that these plants derive a far greater portion of their nourishment from the atmosphere and from water than cereals do, and that they adapt it to their use by means of their organs. I cannot go so far as to affirm, with some persons, that vegetables derived from the soil appropriate and apply to their nourishment a peculiar substance, which is rejected by all kinds of cereals; but certain it is that the proportional quantity in which they absorb the primitive substances is different. General experience teaches us to regard these substances as fallow crops, or crops which ameliorate the soil, and the alternate cultivation of which and of grain crops tends to maintain it in good condition, and ensure far more luxuriant corn crops than could be obtained if grain were always cultivated. It would be superfluous to add anything to what we have already said in the first volume of this work respecting the necessity of a rotation of crops, for every experienced agriculturist well knows that even good manuring will not maintain land in good condition on which consecutive crops of grain alone are cultivated, and that an alternation of vegetable crops with these is absolutely necessary.

THE PEA.

The pea is the kind of pulse most generally cultivated among us.

There are two principal varieties: the yellow, which is chiefly used in this country, and the gray, or Prussian pea, which is chiefly cultivated in Prussia and Poland.

The yellow pea furnishes us with another variety, which, even when dry, preserves its green hue, but is not otherwise distinguished.

Gardeners raise new varieties of this vegetable every year; but their characters are not permanent, and they speedily degenerate unless cultivated with great care. There are some kinds in which the pods form and ripen early, and the haulm is not so strong as in others. These are looked upon as a more certain crop; the husk of the pea is thought to be finer, and the pea itself more tender; but the larger and later variety often yields the greatest amount of produce, both as regards peas and haulm. That, however, to which, in the majority of cases, preference should be given is the early variety; it not being so liable to be attacked by mildew before the pods are formed, and from being ready to be gathered early, leaving more time for the preparation of the soil and the sowing of the crop which is to succeed to it.

The gray Prussian pea, which is large and angular in shape, and bears a violet colored flower, is said not to bear change of climate, and to degenerate. In Line and Weser, a gray pea, bearing violet colored flowers, is cultivated; but it is grown almost exclusively as fodder for cattle, and considered to be unfit for the use of man on account of its unpleasant taste. This is probably a variety of the Prussian pea.

The yellow pea, for the most part, bears white flowers; some, however, bear violet colored flowers speckled with black. Many persons are of opinion that this has been occasioned by some cross with vetches; but from what I have observed, such cannot be the case, and the alteration of the color of the flower arises from something in the soil or temperature not hitherto discovered.

A clayey, sandy, or calcareous soil, which is not too much exposed either to cold, wet, or drouth, is doubtless the best for peas; this pulse will, however, succeed on stiff as well as on sandy clays, when the latter are not too dry, and the weather is favorable. But in all situations calcareous particles seem to be favorable to its vegetation, even when they only exist in small, or even in minute portions. In many countries peas have only been found to succeed on such soils as had been ameliorated with lime or marl, and the effect has been perceptible even where a considerable period had elapsed since the manuring of the soil. On the other hand, they do not appear to be able to bear the slightest degree of acidity in the soil; and hence the beneficial effects of lime and marl on this kind of crop, may arise chiefly from the tendency of those substances to destroy all acidity.

In the triennial rotation, peas are cultivated on the fallow; this usage is established in almost every place where the soil is adapted for the production of peas. It cannot, however, be denied that after peas the crop of autumnal corn is not usually so luxuriant as it would have been after a fallow; and the soil is more infested with weeds, especially if peas have frequently been sown on that place, instead of a summer fallow and plowing being given. This circumstance causes many persons to be found who are so attached to the old plan that they will sow their peas on the di-

vision intended for spring corn, rather than on a fallow; and then cause the peas to be succeeded by a dead fallow, in order to be able to point out the luxuriance of their crops of autumnal corn to the partisans of fallow crops. These adherents of the old system have even gone so far as to attribute the pretended scarcity of corn, and its dearness for some years past, to the custom of sowing peas on the fallows. But, provided that the peas do not come too often, and the tillage of the fallows is not altogether neglected, and the soil is properly tilled both before and after the pea crop, there is no danger to be apprehended; and the slight diminution which is visible in the produce of the autumnal corn will be doubly and trebly compensated by the produce of the peas, while the impoverishment which they may occasion will be amply atoned for by the amelioration arising from their haulm.

In alternate rotations with pasturage, peas have long been placed after all the other crops, and cultivated on the last division, or that which precedes the repose, and have in general succeeded but badly; but a better system is now pretty generally coming into practice.* It is an undoubted fact, that peas succeed remarkably well on the stubble of clover, and after any weeded crop—as potatoes, for example. But both of these also form an excellent preparation for corn; consequently, between them and the peas a crop of wheat is usually taken. Some persons are of opinion that peas never succeed well on land where they have not been sown before, and, consequently, always sow them in the same places. This, however, is mere prejudice, unless there are other causes which render the rest of the fields unfit for the production of peas. Others, on the contrary, fear lest the peas should degenerate, if they or any similar leguminous crop are sown too frequently on the same spot; but there is nothing in experience which tends to confirm this, and all fear of evil may be avoided by manuring the land between the two, and bestowing proper tillage upon it.

There are various opinions as to whether peas ought to be cultivated as a first, second, or third crop after the soil has been manured. Many farmers fear that, by sowing them immediately after an amelioration of manure, they shall only obtain an abundance which will grow and flower without bearing any pods or yielding any seed. Those whose land is so rich as on average years to lead them to apprehend this evil, will do well to abstain from manuring for peas. But such is by no means a usual case; and even though the produce of the grain crop should be slightly diminished, it is desirable that the peas should vegetate luxuriantly, on account of the great utility of the haulm, and the fertilizing influence which its shadow exercises on the soil when the crop is thick and vigorous.

On land of an average quality, peas which have been manured are always infinitely superior in point of quantity as well as haulm to any others, and they then leave the soil in a condition peculiarly favorable to the succeeding crop; for it is well known that a scanty crop of this vegetable leaves the soil infested with weeds. It is, however, seldom advisable to manure very plentifully for peas.

Every year fresh comparative experiments have furnished us with additional proofs that manure, whether decomposed or fresh and strawy, when spread over the soil after the sowing, is not only more advantageous to peas sown on sandy clays than it would have been if buried by a plowing, but that it is also more beneficial to the grain crop which is to succeed the peas. Experience has demonstrated in a striking manner that all those theoretic principles which appear to contradict this fact, fall before it. I cannot, however, extend this practice to stiff, clayey soils; for I am not aware that any experiments have been made, for the purpose of testing its efficacy on land of that description.

Another mode of proceeding is to bury the manure with the peas, and for this purpose the peas are sown broadcast on the manure after it has been spread.

It has been observed, those crops of peas which have been manured with the dung of sheep or horses are always finer flavored and have a thinner husk than of such as have been sown on the manure produced by cattle and pigs. Ameliorations of lime and ashes are productive of similar advantages.

Although it is universally admitted that peas thrive best on a loose, well pulverized soil, nevertheless many agriculturists have become convinced by experience, that when sown on one plowing, they succeed better than after the most elaborate tillage. I do not intend to deny the truth of the experiments adduced in support of this; but what I say is, that there were, undoubtedly, some particular circumstances which influenced the result, and I cannot receive these statements as any foundation for a general rule. Where a damp soil has been broken up before the commencement of winter, the upper layer of earth is very likely to become so saturated with water as in the spring to render it impossible to plow it for the reception of seed, without turning it into clods instead of dividing it. The farmer does not wish to depart from that rule which prescribes that the seed shall be sown as early as possible, and, consequently, throws the peas into a soil which the plow has hardened instead of loosened, and which is by no means adapted for the reception of this kind of pulse. On land which is not subject to this inconvenience, and where the farmer need not begin to plow the ground which was broken up before the commencement of winter, until it is sufficiently dry to benefit by that operation, a crop sown on two plowings is always finer and better: and though a great quantity of weeds come up, the peas always get the upper hand. The practice of drilling peas is decidedly more advantageous than any other on dry land.

It is usually advisable to sow peas as early in the year as possible; in fact, they are the first crop which should be got into the ground in the spring. Frosts do not injure them, even when they have begun to come up. I have not however, found it injurious to peas to sow them late in the spring; on the contrary, I must confess that those which I have sown in May have always succeeded best, at least, so far as regards the produce in haulm. I do not, however, make it a rule to sow them late, because the success of the crops I have just mentioned always appeared to

* See "Das gerechte Verhaeltniss der Viehzucht und des Ackerbaues." S. 146; "Annalen der Mecklenburgischen Landwirthschaftsgesellschafts." B. 11; S. 276.

me to be chiefly owing to the state of the weather. Peas which are sown early in the season, we are told, escape the attacks of mildew previous to the formation of the pods, and, consequently, their grain is but little injured, although the vegetation of the plant is arrested. But I have invariably observed, that this disease does not attack the late peas which are in full vigor, while it destroys the early ones. Eckardt advises that the peas should not all be sown at once, but a period of nine or fifteen days suffered to elapse between each sowing, by which means the whole crop will be prevented from failing. I cordially agree with him in this opinion, and, at the same time, make it a rule never to sow while the ground is very damp, or when the furrow-slice hardens instead of dividing on being turned over by the mould-board. The quantity of seed usually sown for peas is from a bushel to twenty metzen per acre. It is calculated that when a bushel is sown twelve grains fall on every square foot, which would be too much if spread uniformly over the surface. When peas are sown on furrows, a certain portion cannot be prevented from remaining uncovered, and becoming a prey to birds, which are so greedy after this grain, that they will even dig it up after it has been buried. When peas are sown under furrows, this evil is not so much felt, although even then it cannot be altogether prevented, and the peas germinate much sooner. This, of course, makes a difference in the quantity of seed which it is necessary to sow. It has also been observed, that when a great deal of rain falls during the flowering season, those peas which are not too crowded set, or pass from flower into fruit, and bear much better than those in close, thick-set crops; while these latter yield most haulm, and leave the soil in a better condition. It is, therefore, requisite to ascertain with what view the peas are sown, before we venture to determine whether it is most beneficial to sow thickly or not. Some agriculturists pretend that they destroy the weeds by sowing their peas as thickly as possible, and, therefore, use two bushels of seed per acre; but I do not believe that they attain the end in view by this means, for the weeds, and especially the wild mustard, spring up and vegetate much more quickly than the peas, unless a very favorable season accelerates the growth of the latter.

Some agriculturists have strongly advised that peas should not be harrowed after they have begun to come up; while others, and especially Dullo, in his excellent treatise upon Agriculture, have as strongly recommended this practice as a means of destroying those weeds which are then appearing above ground, and only stipulate that the operation shall not be performed until the plants begin to put forth their leaves. In those experiments which I have made relative to this point, I have never been able to discover that the plants were at all injured by the harrowing; neither could I discover that it had made much effect on the weeds, for they were too deeply rooted in the soil. Perhaps the best mode of proceeding is not to harrow at all after the peas have been sown under furrows, until they begin to come up and develop their leaves, and then the passing of the instrument over the rough plowed land will, perhaps, succeed better in destroying the weeds. But I have not as yet put this plan into practice. Dullo, in his work which I have before alluded to, states that he has plowed peas into the ground, with great success, eight or ten days after they were sown, and consequently after they had begun to germinate; and that these peas came up well, and were peculiarly free from weeds.

In England, peas are frequently cultivated with the hand-hoe; and those which have been sown broadcast, are thinned. Small farmers frequently weed these crops. It would be impossible for us to bestow all this care on them, for we usually sow peas on immense extents of land.

When the wild mustard and radish have shot up so fast as almost to stifle the peas, and are in full vegetation, I have, in common with other agriculturists, had them mown; but the tops of the peas cannot be prevented from also suffering from this proceeding. When, however, the soil is rich and the weather favorable, the crop is rather benefited than injured by it; but under opposite circumstances the peas suffered greatly, and the weeds again get the upper hand.

Weather and temperature have a greater influence on the success of peas and on their formation than on almost any other field crop; hence it is scarcely possible to calculate the average produce which a crop will yield. Damp weather during the flowering season is rather beneficial than injurious, because the comformation of the flower protects it from the introduction of moisture. In dry weather the flower very frequently dries up without setting.

It is very unfortunate if at the flowering season the crop is attacked by mildew; where such is the case, a very promising crop will in four-and-twenty hours often be completely destroyed, and all the flowers will fall without setting. Occasionally there appears to be some matter in the air which acts on the plants in a maner as yet unknown to us, and prevents the formation of the grain; this is frequently observable in buckwheat, as well in other crops.

Some persons stick field peas as they would garden peas. This mode of proceeding certainly prevents the crop from being laid, and facilitates the formation of the seed, but it greatly increases the amount of labor required.

In a few places, the farmers are in the habit of covering a field sown with peas with a layer of straw, and then leaving the peas to make their way through it, and then vegetate; by this means the weeds are all stifled, the soil kept moist, and those stems which fall to the ground prevented from rotting. Where there is a plentiful supply of straw, this may be done with advantage, and the straw will afterward be available as manure.

It is necessary to embrace the exact period at which the peas are ready to be cut without loss of time. In general, the best way is to be guided by the maturity of the early pods, without noticing the later ones, otherwise the largest and best of the crop is liable to be lost. The only exception to this rule occurs when the state of the temperature has been such as only to admit of a few of the first flowers setting, while the later ones, having encountered more favorable weather, have been more successful. But such cases rarely occur; it much oftener happens that the peas are still green and in flower at the top, while the lower pods are ripe and dry. The farmer must not, on any account, wait for the later flowers to come to maturity, for the plants will continue to flower until all the inferior pods have shed their seed. These late flowers are by no means injurious, if they do not mislead the farmer and prevent him from mowing at the proper season. The straw is

then better and more nourishing, and those peas which have not ripened may be made useful in various ways. The only thing which is difficult, is to dry the haulm thoroughly.

When the peas are laid, it is very difficult to mow them. The sickle is the best instrument that can be employed for this purpose.

When the weather is unfavorable, it is very difficult to dry the haulm. During alternate rains and sunshine the pods open, almost the whole of the grain is shed on the field, and nothing is left to be carried but the haulm or straw; this is particularly the case when peas are left in the wads or wisps, and frequently turned with the intention of drying them. When weather of this kind comes on, I have always found it best to cock the peas as soon as ever they began to fade; and if the rain continued, to content myself with raising them a little with the handle of a rake, and to leave them in the same place until they were sufficiently dry to be carried. It cannot be denied that the straw loses some of its goodness under this mode of proceeding; but then there is less harm to be feared in other respects, and the peas are prevented from shedding their seed and leaves. When the weather is fine, it will be found most advantageous to leave the peas in the wads or wisps to dry; and, if necessary, to do so with the hand and not with a rake.

As it is of the utmost importance to the succeeding crop that the land should be plowed as soon as possible after the peas have been mown, it is best to lay these latter on as narrow strips of earth as possible, in order that, if the getting in of the crop is delayed, the intervening spaces may be plowed without loss of time. However tiresome this mode of proceeding may appear to be, every agriculturist who is aware of the importance of breaking up the pea stubble with as little delay as possible will not neglect this precaution.

Some persons tie the peas before carrying them, but this is a very useless trouble.

The produce of the pea in ripened seeds is so casual that it is almost impossible to lay down any general average with regard to its amount. From some fields I obtained thirteen and a half bushels of seed one year, and only two and a half bushels on another, although both times the same routine of cultivation was pursued. On good soils, from five to six bushels may be regarded as an approximative average of the produce per acre.

The price of peas is as variable as their produce. Sometimes it is equal to that of rye; at others, much higher. Provided that the peas are not attacked by worms after being brought into the granary, they may be kept in casks for a considerable period; and, indeed, it is as well to preserve them, as there will always be a supply in hand to meet the exigencies of any year in which this kind of crop fails.

I cannot either state what is the general average between the proportion of grain and of straw, for sometimes the amount of one, and sometimes that of the other predominates. When the soil is good, and has been well manured, we may, however, always reckon with tolerable certainty upon a good crop of straw if not of seed, and, as in most farms straw is of the greatest importance, and chiefly prized, the agriculturists cultivate peas with a view of obtaining it, and receive a good crop of grain as an additional blessing. A good, well-tilled field sown with peas will yield from twelve to sixteen quintals of haulm per acre, unless a period of dry weather impedes the vegetation before the time when it naturally would stop; under peculiarly favorable circumstances, even more than this may be obtained.

Pea-haulm is considered to be peculiarly adapted for sheep; many farmers give it instead of hay, but this can only be done when the greater part of the haulm was green at the time of its being mown. In general it is more bulky and nourishing than the straw of any of the cereal grasses. Pea-haulm is also given to horses and cattle; but for them it must be chopped, because the stems are usually too tough to admit of their being easily masticated, and they are apt to slip between the teeth. The refuse which is left after the peas have been threshed is likewise very nutritious. It is always best to consume the pea-haulm before any other kind, and not to keep it until the spring.

THE LENTIL.

There are two varieties of the common lentil; one small and of a brownish hue, and the other large and more inclined to yellow. The small variety has an aromatic flavor which is peculiar to it, and this causes it to be preferred by many persons; the other, however, finds the readiest sale. These two varieties are very frequently crossed, and thus a mixed lentil is produced which is the one most commonly grown. The quality of the soil has a considerable influence upon the size of the seed.

Latterly the Provence lentil, which is almost as large and of the same color as the pea, has been recommended. It yields a larger produce than the others, both in straw and grain, even when sown on sandy soils, but has very little of the flavor of a lentil, and more resembles the taste of a pea, which, causes it to be much sought for as a dish for the table. As it grows very tall, it answers almost as well on sandy soils as vetches; and I consider it as a better product, whether cultivated as fodder or for the sake of its grain.

Lentils require a soil containing a tolerable proportion of sand, and which is in good condition. They seldom thrive on clayey soils.

This crop is sown later than peas on account of its suffering more from cold. Twelve metzen of seed per acre will be found sufficient; but care must be taken that this seed is pure and not intermingled with the seed of vetches, or the sale of the lentils will be injured. As the haulm of lentils is delicate and feeble, the plants are very liable to be choked by weeds, unless the ground is kept carefully weeded. Many persons dibble lentils in rows, leaving room for a rake to pass between; for my own part, I can see no reason why this crop should not be sown with a drilling machine, and afterward cultivated with a horse-hoe.

The lentil contains a greater proportion of vegeto-animal matter than any other vegetable, and is universally regarded as being highly nutritious. From the time of Esau up to the present day it has been considered as an article of food. This vegetable fetches a higher price than peas; and

as, when grown on a soil which has been properly tilled and is adapted for their reception, they yield from eight to ten bushels per acre, their culture is very lucrative. They do not yield much straw; but what there is, is very delicate and nourishing, and somewhat similar to the best hay; consequently, it is usually reserved for young animals, as lambs and calves. As lentils require to be kept very free from weeds, the culture of this crop tends to improve and clear the soil.

KIDNEY-BEANS (HARICOTS.)

A great number of varieties are cultivated in gardens, the pods of which are generally gathered while green. Dwarf species are cultivated in the fields. As these require all the attention of garden cultivation, and must be carefully trained and weeded, they may be said to be unfit for field crops, and can only be cultivated, to any extent, by means of implements adapted for the purpose.* It is on this account that we merely allude to them here, reserving what farther appertains to the subject until we come to treat of the cultivation of maize, with which that of haricots may be advantageously associated.

BEANS (VICIA FABIA.)

Numerous varieties of the *vicia fabia* are cultivated both in fields and gardens, but the small round variety which bears so many pods, and is known by the name of the horse-bean, is most common. It varies in color, verging sometimes on yellow, at others being of a dark-brown hue, and at others spotted with various shades; but this difference of color is not permanent, and has no influence on the other properties of the bean.

The bean requires a rich, strong, loamy soil, similar in quality to wheat land; it may, however, be cultivated with advantage on lands which are not quite so strong, provided that they are tolerably moist, and contain a large quantity of humus, and that humus is not of too acid a nature; for I have found that beans are subject to rust. Beans serve to loosen stiff soils; the filaments of their roots will penetrate even the hardest clay. Hence they have been regarded as an excellent preparation for wheat on land of this description. Their roots and the shadow of their leaves and haulm serve to keep the soil loose and clear.

When the soil appears to require amelioration, it must be manured for this crop, and that somewhat plentifully; for beans require a good soil, and will bear a considerable quantity of manure.— This plant will make its way through the most tenacious soils, and therefore may be buried with the manure, and by the first plowing. It has even been attempted, and not without success, to sow beans on a tenacious and compact turf, and plow them in; and they have invariably been found to make their way through. There is not, however, any doubt but that they are benefited by a second plowing; and the reason why this is not more frequently bestowed is, that most persons consider it to be absolutely necessary to get the seed into the ground as early as possible; and, therefore, clayoy soils which have been plowed up in the autumn do not dry soon enough in the spring to admit of their being plowed before the seed is got into the ground.

It is generally believed that those beans which are sown earliest thrive best; and consequently, when the weather will admit of it, they are sown in December; for most persons are of opinion that, even though they may suffer from frost, and their leaves become yellow and wither, other leaves will replace these, and, on the whole, the plants will not suffer. I cannot exactly coincide with this opinion, since it has always appeared to me that the beans which have been sown the latest thrive the best.

As the grain is very large, a considerable quantity of seed is often required—often as much as from two to three bushels per acre. English agriculturists say that on strong land which is moist, beans should be sown far apart; and on light, dry soils near together, in order that in the latter case they may overshadow the whole of the land. The plants do not bear so many pods when sown closely, as they do when sown far apart.

Beans are everywhere cultivated as a preparatory crop, or instead of the fallow crop. Sometimes a meadow which is newly broken-up is devoted to them, or they are sown as the first crop on land which has been left in repose or laid down for pasturage, and which is afterward to be sown with grain.

When beans have been buried with the plow, the harrow must only be passed very lightly over the ground; but as soon as they begin to come up and put forth their leaves, they should be well harrowed. Beans will bear a pretty good harrowing with an iron-toothed harrow; for even those which are broken off or torn by this operation will shoot afresh.

While young, they require to be kept perfectly free from weeds; and where this cannot be effected by harrowing, the crop should be hoed if we would have it succeed. In some places recourse is had to the singular proceeding of turning the sheep on to the bean fields when the plants are about two inches above the ground. These animals will not touch the beans so long as they can find a single morsel of anything else to eat.

The practice of sowing beans in rows is adopted even in places where the proper machines for accomplishing this operation and horse-hoes are unknown. Where they have no drill-machines, the beans are sown by hand in every third or fourth furrow drawn by the plow, and about two bushels of seed per acre are used. When the beans have begun to come up, a plow is passed along each side of every line, in order to throw the earth off the plants; and in a short time afterward this implement is again used in an opposite manner to heap the earth round the plants. A plow or a binoir is best adapted for the performance of this operation; I have, however, seen it very well accomplished with a common wheel-plow. The rows are sometimes as much as three

* Those kinds of haricots which do not grow very tall, never require sticking; and, as their stem is stronger than that of peas, they may be more easily cultivated with the horse-hoe during the early periods of their vegetation. These dwarf varieties are, therefore, well adapted for being sown and raised in open fields, and on all farms or agricultural undertakings where an improved system of Agriculture is pursued.

[*French Trans.*

feet or more apart. But the plants are sown very close to one another in rows. There cannot be a doubt but that the crops can be sown in this manner much better with the proper implements, and that less seed will then be required; twenty metzen per acre will be found to be amply sufficient.

Beans which have been drilled, and subsequently cultivated with the horse-hoe, yield a much larger produce in grain than those which have been sown by broadcast; on an average, the former may be said to yield twice as much as the latter. They bear pods even down to the very bottoms of their stems, while those which are sown too closely never do. It is not unusual to find from thirty to forty pods on each plant sown by a drilling-machine, while those sown in the other way rarely bear more than ten. As the lower flowers set early, they escape the attacks both of rust and mildew, which diseases often prevent the later flowers from bearing pods or seed. But the haulm of beans sown in rows is decidedly inferior to that of those sown broadcast; the lower part of the stems becomes hard and ligneous, and the leaves are more apt to fall. But the loss thus experienced bears no comparison to the increase of produce in grain; besides, it may, in a great measure, be avoided by training the plants a little earlier.

The cultivation bestowed on a bean crop keeps the soil clear and loose during that period; and when the plants come up they overshadow it. By this means it is perfectly prepared for the next crop; and after the beans have been gathered in, requires comparatively little tillage. The extirpator is the best instrument which can be made use of for the purpose of leveling land which has been thrown into ridges by drilled crops. When this has been used, one plowing will suffice to prepare the land.

When beans are sown broadcast, they are usually mixed with either peas or vetches, and rarely sown alone on account of their success being so very casual.

This plant is extremely subject to attacks of rust or mildew, or both. The former shows itself on the leaves, the tips of which turn brown; this spreads, becomes darker, and finally destroys both the leaves and the plant. Mildew attacks the tops of the plants, and is immediately followed by the appearance of an innumerable quantity of black insects or bugs *(aphides)*, which soon extend themselves over the whole of the plant, and prevent it from forming any fruit. Some farmers have endeavored to diminish this evil by cutting off the tops of the plants with some sharp instrument. I have never found those crops of beans which have been sown with a drilling-machine to suffer so much from rust or mildew as those sown broadcast; for, in the former case, the plant is usually pretty strong before the disease appears, and a considerable quantity of its grain is formed; consequently, the ravages are not so sensibly felt.*

In places where the worth of the soil is known, when the bean crop promises to turn out badly, it is immediately cut and the field broken up, and the beans spread in the furrows and covered over, because a poor crop of beans would not repay the injury which they would do to the succeeding wheat crop; for it is well known that it is only those bean crops which succeed well, that form a good preparation for wheat, and that this grain almost invariably fails when sown after a poor crop of beans.

Beans should be got in as soon as the greater part of the pods turn black, and without regard to the maturity of those which were set last. A very clever English agriculturist has even gone so far as to recommend that the beans should be cut as soon as the seed is completely formed, tied up, carried to some place, and there left to ripen, in order that the land on which they grew may be the sooner plowed up. Beans sown by broadcast are frequently cut down with a scythe, and then collected and carried out of the field; but a sickle is often made use of. Beans which have been drilled in rows, and especially such as have been well hoed, can only be cut with a sickle; a scythe would break the lower pods, and the beans would then fall into the deep furrows which the hoe had left between the rows, and thus be lost. The best plan appears to me to be to have them pulled up; but this cannot be done on tenacious soils, at least not without great difficulty.

After the beans have been cut they are tied up in small sheaves, five, six, or seven of which are set up one against the other: when the bean harvest is not succeeded by very dry, warm weather, it frequently takes a long time to dry thoroughly. But as it is now well known that it is of the utmost importance that the field should be cleared with as little delay as possible, the beans are often carried to some other place to complete the process of drying.

The produce of beans sown broadcast is even more casual than that of peas. Where the ground is adapted for them, and the plants are sown in rows, and subsequently cultivated with a horse-hoe, from ten to twelve bushels of grain per acre may be expected. In Kent, and other counties of England in which beans are sown, from eighteen to twenty-seven bushels per acre of our measure is regarded as the ordinary amount of produce.

A bushel of beans weighs from a hundred to a hundred and three pounds. They contain a large proportion of nutritious vegeto-animal matter, although not so much as peas; but a larger quantity of amidon. In many places they are baked, and employed as food; sometimes they are even mixed with flour, and made into bread; and many assert that they communicate a most agreeable flavor to the bread thus formed: but this pulse is chiefly given to horses. In many parts of Germany, beans sown broadcast are kept expressly for this purpose, without being threshed; and the sheaves are cut up with the chopped straw, expressly to be given to horses. In England beans are regarded as the best of all kinds of fodder, not only for draught, but also for race-horses. They must not, however, be steeped in water, as some persons are too much in the

* With us, the aphides begin to show themselves on the leaves about the 20th of May. At this period the crop should be carefully looked over every day; and if a few lice are perceptible, which usually precede the insects by a few days, women and children should be immediately sent into the field to nip off the top of every bean plant, and carry it away. Where these laborers make use of both hands at once, the work may very soon be done, and at very trifling expense. Every thing else must be set aside in order to attend to this, for the loss of a day or two might cause the destruction of the whole crop. I have always found the flowers of plants which had been thus cropped to set better than any others. [*French Trans.*

habit of doing, in order to swell them out, but given in their natural state. They are also made use of for the purpose of fattening pigs, and are exceedingly adapted for this; but then they should be soaked in water.

Bean straw is usually considered to be very nutritious, especially when it has not suffered from the effects of unfavorable weather; this, however, depends very much upon the period at which the crop is cut, upon whether it was cut while the haulm was yet green, or later in the season; thus, in the latter case, the leaves will have fallen off, and the stems become hardened. In the former case, bean straw is considered as equal to hay, and is given to horses and sheep as such. With regard to the straw of drilled beans, as I have before stated, it often loses its quality. In this kind of produce the relative proportion of the quantity of straw to that of grain is almost always opposite.

VETCHES. COMMON VETCH (VICIA SATIVA).

Among the numerous family of vetches there are various kinds which are doubtless useful; hitherto, however, none have been much cultivated excepting the common vetch, the Narbonne vetch *(vicia Narbonensis)*. The cultivation bestowed on the latter in no way differs from that bestowed on the former; and as it appears to be in no way superior to the other, excepting in cases where it is wished to cultivate vetches on very rich land, it is but little grown. After several experiments I have given up the saw-leaved vetch *(vicia serratifolia)*, on account of its not having come up to my expectations.

There are several varieties of the common vetch. We have a small one which ripens very early, and one, the haulm of which is larger, which ripens late, and requires to be sown very early in the year to ensure its arriving at maturity.

The English autumnal vetch is probably the same as this large variety, but has by cultivation become habituated to passing the winter in the ground. Several experiments which have been made in our climate seem to demonstrate that this vetch is incapable of resisting the winter: it is less liable to be destroyed by sudden hoar-frosts, than by late frosts which occur after vegetation has commenced. It not unfrequently happens that even in England it is destroyed by frost; thus the advantage which might be derived from that naturalization of this species would not be very great, since it seldom ripens more than ten days before the spring vetch, when this latter has been sown in good time.

Vetches require a clayey soil, where the land contains more than sixty parts in a hundred of sand, and is not in a very damp situation; this plant will also thrive, provided that the ground is properly ameliorated, and the summer moist; but in dry summers it rarely succeeds.

It does not absolutely require a very rich soil; nevertheless, it always succeeds better, and the haulm is finer, when the soil contains a considerable portion of succulency; it is on this account that wherever it is practicable they manure for this crop.

This plant is now almost as often cultivated for its haulm as for its seed, which former is either used as green meat or reduced to dry fodder; it is cut while in flower, and before many pods are formed.

The cultivation of this crop is in no way distinguished from that of peas; as the seed is smaller, twelve metzen is sufficient for an acre of ground. In order to ensure its attaining maturity, the large vetch ought to be sown at the beginning of April. The small variety will ripen, even when not sown till the end of May; but most agriculturists recommend that the common variety should be sown early. I have, however, observed these crops for some years past, and have always found that where this kind of vetch had not been sown until toward the middle of May, it always succeeded better than when sown earlier. If cold weather comes on, the vegetation of the plants is checked, and then they are very frequently attacked by a worm, which gnaws the buds, and does so much mischief that if the soil is at all impoverished, the plants never flower; where, however, it is rich, the plants occasionally overcome this evil, and shoot up again. Those vetches which are sown later escape the attacks of this worm, the period of its existence being short.

Where it is intended to use vetches as green fodder, or reduce the crop to hay before it has attained its maturity, it may be sown in any weather up to the beginning of July. In order to be enabled to stall feed cattle on green vetches, a certain quantity must be sown which will last until the others come up. When intended for this purpose, the vetches are usually mingled with spring rye, barley, or oats; and to these latter is often added buckwheat, in order to render the mixture thicker and richer. When the crop is to be made into hay, it is considered most desirable to sow the vetches by themselves, as it then dries more uniformly. This crop is made into hay in the same manner as clover or lucerne; consequently I shall refer my readers to the directions which will be given when I come to speak of the haymaking of these crops. Vetches take longer drying than clover, but are not so liable to be spoiled when the process of drying is not properly conducted.

When vetches are intended for the feeding of horned cattle, in the shape of green meat or dry fodder, they are mown while in full flower; but when they are intended for horses, the pods are suffered to develop themselves a little, because the quantity of fodder is thus increased, and the vetches rendered more nutritious.

The sooner vetches are mown the less do they impoverish the soil. But whenever this plant has been sown, the ground must be broken up directly the crop has been got in; the importance of this course is so generally known and recognized, that all persons who have it in their power, cause the newly mown plants to be immediately conveyed to some other place to be dried.

When vetches are mown early in the season, and at the time when they are putting forth their first buds, they will shoot again if the soil is rich; but where it is poor, nothing is gained by such a proceeding; on the contrary, the two cuttings together do not amount to as much as would have been obtained from one good crop cut at the usual period.

It is a very bad practice to endeavor to derive advantage from the second shooting of vetches by pasturing cattle on them, as the soil is then hardened by the feet of the animals, and the succeeding crop is thus often seriously injured. Occasionally a second crop of vetches is sown on land which has produced one that has been mown while green; but in order to do this the utmost promptitude is necessary, and not a moment must be lost between the gathering of one crop and the sowing of the other. But, in general, buckwheat or radishes are sown after vetches which have been cut while green.

The produce of vetches in seed is very unequal. Sometimes as much as twenty-four bushels per acre have been obtained; but eight bushels may be regarded as the average quantity. Vetches grown on rich land have yielded as much as from 1,800 to 2,000 lbs. of straw, comprehending the husks and refuse. The haulm of this crop is preferred to pea haulm for the purpose of feeding cattle. When vetches are cut while green, and at the period when their pods are just beginning to form, 3,000 lbs. of straw per acre are often obtained; but even where the soil is most fertile, it is safest only to reckon on 2,000 lbs. When on account of the spring being very dry the vetches do not succeed, the produce will fall to 1,000 lbs. per acre.

Numerous experiments seem to testify, that when cut while green, vetches scarcely deprive the soil of any portion of its fertility, but that, on the contrary, the succeeding crop has often been found to be decidedly better than one which followed a dead fallow, provided, however, that the ground has been broken up without loss of time after the gathering of the vetches. Vetches which attain maturity, and yield a produce in grain, may, in that respect, be compared with peas. The common mixture of vetches and oats, when suffered to attain maturity, exhausts land much more; and a crop of rye grown on a field which has produced this kind of fodder, and from which it has been mown little by little, as it was required, will indicate very plainly by the difference in its produce which were the spots on which the vetches and oats were suffered to stand too long. In England it is by no means unusual to sow vetches solely for the purpose of ameliorating the soil. In such cases, however, this crop is not plowed in at once, but cattle intended for fattening, and pigs, are turned on to it; which animals certainly spoil a great deal by trampling it down, but they also consume a great deal. After this the land is broken up without loss of time, and sown with rape. This mode of proceeding is not in some respects so little economical as it appeared to be to a traveler with whom I am acquainted.

When vetches have been left standing till their seed is ripe, they are commonly used to feed horses and fatten pigs; they are also given to sheep, and for this purpose are considered preferable to peas. The seed of this plant is rarely a marketable commodity; it is, however, not unfrequently sold for sowing. Vetches may be kept for a long time, and ultimately sold at a price which yields large interest. In agricultural undertakings in which the production of fodder forms an essential feature, it is advisable to keep a supply of vetch seed in the granary, because this plant furnishes the best resource when the crop of clover fails.

The straw of vetches which have perfected their seed is more grateful to cattle than that of peas; it is often, indeed, considered equal in value to hay; but it is not to be compared with vetches that have been mown in the green state and made into dry fodder.

There are a few other sorts of pulse rarely met with, and confined to certain localities; such are the Spanish lentil *(lathirus sativus)*, and the chick-pea *(cicer arietinum)*. The cultivation of these plants differs in no respect from that of peas and vetches, and hitherto I have heard no reason assigned for preferring them to the plants already noticed.

BUCKWHEAT (POLYGONUM FAGOPYRUM).

This plant thrives well on soils which are too poor for all other kinds of grain either of the spring or summer varieties. It grows on dry, sandy soils, provided only that the drouth be not felt precisely at the time when the plant stands most in need of moisture; it then yields as plentiful a crop as any other kind of grain; but if the ground be in a situation somewhat more accessible to moisture, the crop of buckwheat is so much the more to be depended upon. This plant also thrives on heath and marsh lands, provided that the latter have been previously drained. It is cultivated to great advantage on clearings of this description, and is very useful in preparing the soil for the reception of other kinds of grain.

In sandy districts buckwheat is the only crop which succeeds when sown alternately with rye; in such situations it takes the place of all other fallow crops: it is also sown on lands where rye has been grown. It, however, thrives better as a fallow crop on land which has been used as pasturage, or left in repose for a few years.

On richer soils the plant grows more vigorously, but only in the haulm, rarely producing so much seed as when grown on proper soils. A small quantity of manure is advantageous to it; but a large quantity makes it grow too strong in the haulm. When the land on which buckwheat is to be grown requires manuring, it is usual to give it only half the usual quantity, the remainder being reserved till after the harvest.

Manure furnished by furze, a plant which is always abundant in districts where buckwheat is grown, is particularly well adapted to this kind of grain.

The sowing of buckwheat even on the lightest soils, must always be preceded by two plowings, in order to destroy the weeds.

This plant, which was brought from the East at the time of the crusades, has not yet lost its sensibility to cold; the slightest hoar-frost destroys it. The sowing must therefore be deferred till all danger of cold nights is over. I have, however, known buckwheat to be destroyed by frost as late as St. John's day. It should not, therefore, be sown earlier than the middle of May, or later than the middle of June;* for, if sown at a later part of the season, it will be liable to be

* Throughout at least the half of France, in the South of Switzerland, and generally in countries where the corn is housed about the middle of July, and the hoar-frosts seldom begin before the 24th of October,

culency and vitality unimpaired up to the period of its being cut, it is generally much more nourishing than the straw of grain crops. The haulm of these vegetables, too, when cut before the formation of the fruit or seed, yields a far more nourishing fodder than any of the cereals do.

This class of leguminous plants appear not only to be particularly nourishing to men and animals, but even to supply food to vegetables. The great proportion of vegeto-animal matter which they contain, causes them in a great measure to resemble animal manure, to be very easily decomposed by putrefaction, and to enter more promptly into the composition of plants. It is on this account that from time immemorial, they have been used in Europe for the amelioration of other crops. The lupine, which on account of its bitterness cannot be otherwise employed, is the chief one of this tribe which is plowed into the ground as green manure; not only is this plant buried while green, but its seed is made use of for the purpose of dressing olive trees, after having been steeped in boiling water, in order to destroy its germinating principle. Other vegetables are likewise similarly employed.

Besides this vegeto-animal substance, leguminous plants contain starch, and a soluble mucous matter similar to that contained in the grain of cereals, but not so sweet.

The best way of preparing vegetables for food is to boil them. Their various component parts are thus brought into more intimate combination, and rendered more soluble, digestible, and agreeable to the stomach. They gain as much by this mode of proceeding as grain does by fermentation, and by being made into bread. They may themselves be made into bread, but then it has a crude, unpleasant, rancid taste. They are not unfrequently mixed with rye, or wheat flour, and then they render the bread more nourishing without altering its flavor.

There cannot be a doubt but that products which contain so much nutritive matter must deprive the soil on which they grow of a corresponding portion of its nutrition. Nevertheless, it appears that these plants derive a far greater portion of their nourishment from the atmosphere and from water than cereals do, and that they adapt it to their use by means of their organs. I cannot go so far as to affirm, with some persons, that vegetables derived from the soil appropriate and apply to their nourishment a peculiar substance, which is rejected by all kinds of cereals; but certain it is that the proportional quantity in which they absorb the primitive substances is different. General experience teaches us to regard these substances as fallow crops, or crops which ameliorate the soil, and the alternate cultivation of which and of grain crops tends to maintain it in good condition, and ensure far more luxuriant corn crops than could be obtained if grain were always cultivated. It would be superfluous to add anything to what we have already said in the first volume of this work respecting the necessity of a rotation of crops, for every experienced agriculturist well knows that even good manuring will not maintain land in good condition on which consecutive crops of grain alone are cultivated, and that an alternation of vegetable crops with these is absolutely necessary.

THE PEA.

The pea is the kind of pulse most generally cultivated among us.

There are two principal varieties: the yellow, which is chiefly used in this country, and the gray or Prussian pea, which is chiefly cultivated in Prussia and Poland.

The yellow pea furnishes us with another variety, which, even when dry, preserves its green hue, but is not otherwise distinguished.

Gardeners raise new varieties of this vegetable every year; but their characters are not permanent, and they speedily degenerate unless cultivated with great care. There are some kinds in which the pods form and ripen early, and the haulm is not so strong as in others. These are looked upon as a more certain crop; the husk of the pea is thought to be finer, and the pea itself more tender; but the larger and later variety often yields the greatest amount of produce, both as regards peas and haulm. That, however, to which, in the majority of cases, preference should be given is the early variety; it not being so liable to be attacked by mildew before the pods are formed, and from being ready to be gathered early, leaving more time for the preparation of the soil and the sowing of the crop which is to succeed to it.

The gray Prussian pea, which is large and angular in shape, and bears a violet colored flower, is said not to bear change of climate, and to degenerate. In Line and Weser, a gray pea, bearing violet colored flowers, is cultivated; but it is grown almost exclusively as fodder for cattle, and considered to be unfit for the use of man on account of its unpleasant taste. This is probably a variety of the Prussian pea.

The yellow pea, for the most part, bears white flowers; some, however, bear violet colored flowers speckled with black. Many persons are of opinion that this has been occasioned by some cross with vetches; but from what I have observed, such cannot be the case, and the alteration of the color of the flower arises from something in the soil or temperature not hitherto discovered.

A clayey, sandy, or calcareous soil, which is not too much exposed either to cold, wet, or drouth, is doubtless the best for peas; this pulse will, however, succeed on stiff as well as on sandy clays when the latter are not too dry, and the weather is favorable. But in all situations calcareous particles seem to be favorable to its vegetation, even when they only exist in small, or even in minute portions. In many countries peas have only been found to succeed on such soils as had been ameliorated with lime or marl, and the effect has been perceptible even where a considerable period had elapsed since the manuring of the soil. On the other hand, they do not appear to be able to bear the slightest degree of acidity in the soil; and hence the beneficial effects of lime and marl on this kind of crop, may arise chiefly from the tendency of those substances to destroy all acidity.

In the triennial rotation, peas are cultivated on the fallow; this usage is established in almost every place where the soil is adapted for the production of peas. It cannot, however, be denied that after peas the crop of autumnal corn is not usually so luxuriant as it would have been after a fallow; and the soil is more infested with weeds, especially if peas have frequently been sown on that place, instead of a summer fallow and plowing being given. This circumstance causes many persons to be found who are so attached to the old plan that they will sow their peas on the di-

vision intended for spring corn, rather than on a fallow; and then cause the peas to be succeeded by a dead fallow, in order to be able to point out the luxuriance of their crops of autumnal corn to the partisans of fallow crops. These adherents of the old system have even gone so far as to attribute the pretended scarcity of corn, and its dearness for some years past, to the custom of sowing peas on the fallows. But provided that the peas do not come too often, and the tillage of the fallows is not altogether neglected, and the soil is properly tilled both before and after the pea crop, there is no danger to be apprehended; and the slight diminution which is visible in the produce of the autumnal corn will be doubly and trebly compensated by the produce of the peas, while the impoverishment which they may occasion will be amply atoned for by the amelioration arising from their haulm.

In alternate rotations with pasturage, peas have long been placed after all the other crops, and cultivated on the last division, or that which precedes the repose, and have in general succeeded but badly; but a better system is now pretty generally coming into practice.* It is an undoubted fact, that peas succeed remarkably well on the stubble of clover, and after any weeded crop—as potatoes, for example. But both of these also form an excellent preparation for corn; consequently, between them and the peas a crop of wheat is usually taken. Some persons are of opinion that peas never succeed well on land where they have not been sown before, and, consequently, always sow them in the same places. This, however, is mere prejudice, unless there are other causes which render the rest of the fields unfit for the production of peas. Others, on the contrary, fear lest the peas should degenerate, if they or any similar leguminous crop are sown too frequently on the same spot; but there is nothing in experience which tends to confirm this, and all fear of evil may be avoided by manuring the land between the two, and bestowing proper tillage upon it.

There are various opinions as to whether peas ought to be cultivated as a first, second, or third crop after the soil has been manured. Many farmers fear that, by sowing them immediately after an amelioration of manure, they shall only obtain an abundance which will grow and flower without bearing any pods or yielding any seed. Those whose land is so rich as on average years to lead them to apprehend this evil, will do well to abstain from manuring for peas. But such is by no means a usual case; and even though the produce of the grain crop should be slightly diminished, it is desirable that the peas should vegetate luxuriantly, on account of the great utility of the haulm, and the fertilizing influence which its shadow exercises on the soil when the crop is thick and vigorous.

On land of an average quality, peas which have been manured are always infinitely superior in point of quantity as well as haulm to any others, and they then leave the soil in a condition peculiarly favorable to the succeeding crop; for it is well known that a scanty crop of this vegetable leaves the soil infested with weeds. It is, however, seldom advisable to manure very plentifully for peas.

Every year fresh comparative experiments have furnished us with additional proofs that manure, whether decomposed or fresh and strawy, when spread over the soil after the sowing, is not only more advantageous to peas sown on sandy clays than it would have been if buried by a plowing, but that it is also more beneficial to the grain crop which is to succeed the peas. Experience has demonstrated in a striking manner that all those theoretic principles which appear to contradict this fact, fall before it. I cannot, however, extend this practice to stiff, clayey soils; for I am not aware that any experiments have been made, for the purpose of testing its efficacy on land of that description.

Another mode of proceeding is to bury the manure with the peas, and for this purpose the peas are sown broadcast on the manure after it has been spread.

It has been observed, those crops of peas which have been manured with the dung of sheep or horses are always finer flavored and have a thinner husk than of such as have been sown on the manure produced by cattle and pigs. Ameliorations of lime and ashes are productive of similar advantages.

Although it is universally admitted that peas thrive best on a loose, well pulverized soil, nevertheless many agriculturists have become convinced by experience, that when sown on one plowing, they succeed better than after the most elaborate tillage. I do not intend to deny the truth of the experiments adduced in support of this: but what I say is, that there were, undoubtedly, some particular circumstances which influenced the result, and I cannot receive these statements as any foundation for a general rule. Where a damp soil has been broken up before the commencement of winter, the upper layer of earth is very likely to become so saturated with water as in the spring to render it impossible to plow it for the reception of seed, without turning it into clods instead of dividing it. The farmer does not wish to depart from that rule which prescribes that the seed shall be sown as early as possible, and, consequently, throws the peas into a soil which the plow has hardened instead of loosened, and which is by no means adapted for the reception of this kind of pulse. On land which is not subject to this inconvenience, and where the farmer need not begin to plow the ground which was broken up before the commencement of winter, until it is sufficiently dry to benefit by that operation, a crop sown on two plowings is always finer and better: and though a great quantity of weeds come up, the peas always get the upper hand. The practice of drilling peas is decidedly more advantageous than any other on dry land.

It is usually advisable to sow peas as early in the year as possible; in fact, they are the first crop which should be got into the ground in the spring. Frosts do not injure them, even when they have begun to come up. I have not however, found it injurious to peas to sow them late in the spring; on the contrary, I must confess that those which I have sown in May have always succeeded best, at least, so far as regards the produce in haulm. I do not, however, make it a rule to sow them late, because the success of the crops I have just mentioned always appeared to

* See "Das gerechte Verhaeltniss der Viehzucht und des Ackerbaues." S. 146; "Annalen der Mecklenburgischen Landwirthschaftsgesellschafts." B. 11; S. 276.

me to be chiefly owing to the state of the weather. Peas which are sown early in the season, we are told, escape the attacks of mildew previous to the formation of the pods, and, consequently, their grain is but little injured, although the vegetation of the plant is arrested. But I have invariably observed, that this disease does not attack the late peas which are in full vigor, while it destroys the early ones. Eckardt advises that the peas should not all be sown at once, but a period of nine or fifteen days suffered to elapse between each sowing, by which means the whole crop will be prevented from failing. I cordially agree with him in this opinion, and, at the same time, make it a rule never to sow while the ground is very damp, or when the furrow-slice hardens instead of dividing on being turned over by the mould-board. The quantity of seed usually sown for peas is from a bushel to twenty metzen per acre. It is calculated that when a bushel is sown twelve grains fall on every square foot, which would be too much if spread uniformly over the surface. When peas are sown on furrows, a certain portion cannot be prevented from remaining uncovered, and becoming a prey to birds, which are so greedy after this grain, that they will even dig it up after it has been buried. When peas are sown under furrows, this evil is not so much felt, although even then it cannot be altogether prevented, and the peas germinate much sooner. This, of course, makes a difference in the quantity of seed which it is necessary to sow. It has also been observed, that when a great deal of rain falls during the flowering season, those peas which are not too crowded set, or pass from flower into fruit, and bear much better than those in close, thick-set crops; while these latter yield most haulm, and leave the soil in a better condition. It is, therefore, requisite to ascertain with what view the peas are sown, before we venture to determine whether it is most beneficial to sow thickly or not. Some agriculturists pretend that they destroy the weeds by sowing their peas as thickly as possible, and, therefore, use two bushels of seed per acre; but I do not believe that they attain the end in view by this means, for the weeds, and especially the wild mustard, spring up and vegetate much more quickly than the peas, unless a very favorable season accelerates the growth of the latter.

Some agriculturists have strongly advised that peas should not be harrowed after they have begun to come up; while others, and especially Dullo, in his excellent treatise upon Agriculture, have as strongly recommended this practice as a means of destroying those weeds which are then appearing above ground, and only stipulate that the operation shall not be performed until the plants begin to put forth their leaves. In those experiments which I have made relative to this point, I have never been able to discover that the plants were at all injured by the harrowing: neither could I discover that it had made much effect on the weeds, for they were too deeply rooted in the soil. Perhaps the best mode of proceeding is not to harrow at all after the peas have been sown under furrows, until they begin to come up and develop their leaves, and then the passing of the instrument over the rough plowed land will, perhaps, succeed better in destroying the weeds. But I have not as yet put this plan into practice. Dullo, in his work which I have before alluded to, states that he has plowed peas into the ground, with great success, eight or ten days after they were sown, and consequently after they had begun to germinate; and that these peas came up well, and were peculiarly free from weeds.

In England, peas are frequently cultivated with the hand-hoe; and those which have been sown broadcast, are thinned. Small farmers frequently weed these crops. It would be impossible for us to bestow all this care on them, for we usually sow peas on immense extents of land.

When the wild mustard and radish have shot up so fast as almost to stifle the peas, and are in full vegetation, I have, in common with other agriculturists, had them mown; but the tops of the peas cannot be prevented from also suffering from this proceeding. When, however, the soil is rich and the weather favorable, the crop is rather benefited than injured by it; but under opposite circumstances the peas suffered greatly, and the weeds again get the upper hand.

Weather and temperature have a greater influence on the success of peas and on their formation than on almost any other field crop; hence it is scarcely possible to calculate the average produce which a crop will yield. Damp weather during the flowering season is rather beneficial than injurious, because the comformation of the flower protects it from the introduction of moisture. In dry weather the flower very frequently dries up without setting.

It is very unfortunate if at the flowering season the crop is attacked by mildew; where such is the case, a very promising crop will in four-and-twenty hours often be completely destroyed, and all the flowers will fall without setting. Occasionally there appears to be some matter in the air which acts on the plants in a maner as yet unknown to us, and prevents the formation of the grain, this is frequently observable in buckwheat, as well in other crops.

Some persons stick field peas as they would garden peas. This mode of proceeding certainly prevents the crop from being laid, and facilitates the formation of the seed, but it greatly increases the amount of labor required.

In a few places, the farmers are in the habit of covering a field sown with peas with a layer of straw, and then leaving the peas to make their way through it, and then vegetate; by this means the weeds are all stifled, the soil kept moist, and those stems which fall to the ground prevented from rotting. Where there is a plentiful supply of straw, this may be done with advantage, and the straw will afterward be available as manure.

It is necessary to embrace the exact period at which the peas are ready to be cut without loss of time. In general, the best way is to be guided by the maturity of the early pods, without noticing the later ones, otherwise the largest and best of the crop is liable to be lost. The only exception to this rule occurs when the state of the temperature has been such as only to admit of a few of the first flowers setting, while the later ones, having encountered more favorable weather, have been more successful. But such cases rarely occur; it much oftener happens that the peas are still green and in flower at the top, while the lower pods are ripe and dry. The farmer must not on any account, wait for the later flowers to come to maturity, for the plants will continue to flower until all the inferior pods have shed their seed. These late flowers are by no means injurious if they do not mislead the farmer and prevent him from mowing at the proper season. The straw is

then better and more nourishing, and those peas which have not ripened may be made useful in various ways. The only thing which is difficult, is to dry the haulm thoroughly.

When the peas are laid, it is very difficult to mow them. The sickle is the best instrument that can be employed for this purpose.

When the weather is unfavorable, it is very difficult to dry the haulm. During alternate rains and sunshine the pods open, almost the whole of the grain is shed on the field, and nothing is left to be carried but the haulm or straw; this is particularly the case when peas are left in the wads or wisps, and frequently turned with the intention of drying them. When weather of this kind comes on, I have always found it best to cock the peas as soon as ever they began to fade; and if the rain continued, to content myself with raising them a little with the handle of a rake, and to leave them in the same place until they were sufficiently dry to be carried. It cannot be denied that the straw loses some of its goodness under this mode of proceeding; but then there is less harm to be feared in other respects, and the peas are prevented from shedding their seed and leaves. When the weather is fine, it will be found most advantageous to leave the peas in the wads or wisps to dry; and, if necessary, to do so with the hand and not with a rake.

As it is of the utmost importance to the succeeding crop that the land should be plowed as soon as possible after the peas have been mown, it is best to lay these latter on as narrow strips of earth as possible, in order that, if the getting in of the crop is delayed, the intervening spaces may be plowed without loss of time. However tiresome this mode of proceeding may appear to be, every agriculturist who is aware of the importance of breaking up the pea stubble with as little delay as possible will not neglect this precaution.

Some persons tie the peas before carrying them, but this is a very useless trouble.

The produce of the pea in ripened seeds is so casual that it is almost impossible to lay down any general average with regard to its amount. From some fields I obtained thirteen and a half bushels of seed one year, and only two and a half bushels on another, although both times the same routine of cultivation was pursued. On good soils, from five to six bushels may be regarded as an approximative average of the produce per acre.

The price of peas is as variable as their produce. Sometimes it is equal to that of rye; at others, much higher. Provided that the peas are not attacked by worms after being brought into the granary, they may be kept in casks for a considerable period; and, indeed, it is as well to preserve them, as there will always be a supply in hand to meet the exigencies of any year in which this kind of crop fails.

I cannot either state what is the general average between the proportion of grain and of straw, for sometimes the amount of one, and sometimes that of the other predominates. When the soil is good, and has been well manured, we may, however, always reckon with tolerable certainty upon a good crop of straw if not of seed, and, as in most farms straw is of the greatest importance, and chiefly prized, the agriculturists cultivate peas with a view of obtaining it, and receive a good crop of grain as an additional blessing. A good, well-tilled field sown with peas will yield from twelve to sixteen quintals of haulm per acre, unless a period of dry weather impedes the vegetation before the time when it naturally would stop; under peculiarly favorable circumstances, even more than this may be obtained.

Pea-haulm is considered to be peculiarly adapted for sheep; many farmers give it instead of hay, but this can only be done when the greater part of the haulm was green at the time of its being mown. In general it is more bulky and nourishing than the straw of any of the cereal grasses. Pea-haulm is also given to horses and cattle; but for them it must be chopped, because the stems are usually too tough to admit of their being easily masticated, and they are apt to slip between the teeth. The refuse which is left after the peas have been threshed is likewise very nutritious. It is always best to consume the pea-haulm before any other kind, and not to keep it until the spring.

THE LENTIL.

There are two varieties of the common lentil; one small and of a brownish hue, and the other large and more inclined to yellow. The small variety has an aromatic flavor which is peculiar to it, and this causes it to be preferred by many persons; the other, however, finds the readiest sale. These two varieties are very frequently crossed, and thus a mixed lentil is produced which is the one most commonly grown. The quality of the soil has a considerable influence upon the size of the seed.

Latterly the Provence lentil, which is almost as large and of the same color as the pea, has been recommended. It yields a larger produce than the others, both in straw and grain, even when sown on sandy soils, but has very little of the flavor of a lentil, and more resembles the taste of a pea, which, causes it to be much sought for as a dish for the table. As it grows very tall, it answers almost as well on sandy soils as vetches; and I consider it as a better product, whether cultivated as fodder or for the sake of its grain.

Lentils require a soil containing a tolerable proportion of sand, and which is in good condition. They seldom thrive on clayey soils.

This crop is sown later than peas on account of its suffering more from cold. Twelve metzen of seed per acre will be found sufficient; but care must be taken that this seed is pure and not intermingled with the seed of vetches, or the sale of the lentils will be injured. As the haulm of lentils is delicate and feeble, the plants are very liable to be choked by weeds, unless the ground is kept carefully weeded. Many persons dibble lentils in rows, leaving room for a rake to pass between; for my own part, I can see no reason why this crop should not be sown with a drilling machine, and afterward cultivated with a horse-hoe.

The lentil contains a greater proportion of vegeto-animal matter than any other vegetable, and is universally regarded as being highly nutritious. From the time of Esau up to the present day it has been considered as an article of food. This vegetable fetches a higher price than peas; and

as, when grown on a soil which has been properly tilled and is adapted for their reception, they yield from eight to ten bushels per acre, their culture is very lucrative. They do not yield much straw; but what there is, is very delicate and nourishing, and somewhat similar to the best hay; consequently, it is usually reserved for young animals, as lambs and calves. As lentils require to be kept very free from weeds, the culture of this crop tends to improve and clear the soil.

KIDNEY-BEANS (HARICOTS.)

A great number of varieties are cultivated in gardens, the pods of which are generally gathered while green. Dwarf species are cultivated in the fields. As these require all the attention of garden cultivation, and must be carefully trained and weeded, they may be said to be unfit for field crops, and can only be cultivated, to any extent, by means of implements adapted for the purpose.* It is on this account that we merely allude to them here, reserving what farther appertains to the subject until we come to treat of the cultivation of maize, with which that of haricots may be advantageously associated.

BEANS (VICIA FABIA.)

Numerous varieties of the *vicia fabia* are cultivated both in fields and gardens, but the small round variety which bears so many pods, and is known by the name of the horse-bean, is most common. It varies in color, verging sometimes on yellow, at others being of a dark-brown hue, and at others spotted with various shades; but this difference of color is not permanent, and has no influence on the other properties of the bean.

The bean requires a rich, strong, loamy soil, similar in quality to wheat land; it may, however be cultivated with advantage on lands which are not quite so strong, provided that they are tolerably moist, and contain a large quantity of humus, and that humus is not of too acid a nature; for I have found that beans are subject to rust. Beans serve to loosen stiff soils; the filaments of their roots will penetrate even the hardest clay. Hence they have been regarded as an excellent preparation for wheat on land of this description. Their roots and the shadow of their leaves and haulm serve to keep the soil loose and clear.

When the soil appears to require amelioration, it must be manured for this crop, and that somewhat plentifully; for beans require a good soil, and will bear a considerable quantity of manure.—This plant will make its way through the most tenacious soils, and therefore may be buried with the manure, and by the first plowing. It has even been attempted, and not without success, to sow beans on a tenacious and compact turf, and plow them in; and they have invariably been found to make their way through. There is not, however, any doubt but that they are benefited by a second plowing; and the reason why this is not more frequently bestowed is, that most persons consider it to be absolutely necessary to get the seed into the ground as early as possible, and, therefore, clayoy soils which have been plowed up in the autumn do not dry soon enough in the spring to admit of their being plowed before the seed is got into the ground.

It is generally believed that those beans which are sown earliest thrive best; and consequently when the weather will admit of it, they are sown in December; for most persons are of opinion that even though they may suffer from frost, and their leaves become yellow and wither, other leaves will replace these, and, on the whole, the plants will not suffer. I cannot exactly coincide with this opinion, since it has always appeared to me that the beans which have been sown the latest thrive the best.

As the grain is very large, a considerable quantity of seed is often required—often as much as from two to three bushels per acre. English agriculturists say that on strong land which is moist beans should be sown far apart; and on light, dry soils near together, in order that in the latter case they may overshadow the whole of the land. The plants do not bear so many pods when sown closely, as they do when sown far apart.

Beans are everywhere cultivated as a preparatory crop, or instead of the fallow crop. Sometimes a meadow which is newly broken-up is devoted to them, or they are sown as the first crop on land which has been left in repose or laid down for pasturage, and which is afterward to be sown with grain.

When beans have been buried with the plow, the harrow must only be passed very lightly over the ground; but as soon as they begin to come up and put forth their leaves, they should be well harrowed. Beans will bear a pretty good harrowing with an iron-toothed harrow; for even those which are broken off or torn by this operation will shoot afresh.

While young, they require to be kept perfectly free from weeds; and where this cannot be effected by harrowing, the crop should be hoed if we would have it succeed. In some places recourse is had to the singular proceeding of turning the sheep on to the bean fields when the plants are about two inches above the ground. These animals will not touch the beans so long as they can find a single morsel of anything else to eat.

The practice of sowing beans in rows is adopted even in places where the proper machines for accomplishing this operation and horse-hoes are unknown. Where they have no drill-machines, the beans are sown by hand in every third or fourth furrow drawn by the plow, and about two bushels of seed per acre are used. When the beans have begun to come up, a plow is passed along each side of every line, in order to throw the earth off the plants; and in a short time afterward this implement is again used in an opposite manner to heap the earth round the plants. A plow or a binoir is best adapted for the performance of this operation; I have, however, seen it very well accomplished with a common wheel-plow. The rows are sometimes as much as three

* Those kinds of haricots which do not grow very tall, never require sticking; and, as their stem is stronger than that of peas, they may be more easily cultivated with the horse-hoe during the early periods of their vegetation. These dwarf varieties are, therefore, well adapted for being sown and raised in open fields, and on all farms or agricultural undertakings where an improved system of Agriculture is pursued.
[*French Trans.*

feet or more apart. But the plants are sown very close to one another in rows. There cannot be a doubt but that the crops can be sown in this manner much better with the proper implements, and that less seed will then be required; twenty metzen per acre will be found to be amply sufficient.

Beans which have been drilled, and subsequently cultivated with the horse-hoe, yield a much larger produce in grain than those which have been sown by broadcast; on an average, the former may be said to yield twice as much as the latter. They bear pods even down to the very bottoms of their stems, while those which are sown too closely never do. It is not unusual to find from thirty to forty pods on each plant sown by a drilling-machine, while those sown in the other way rarely bear more than ten. As the lower flowers set early, they escape the attacks both of rust and mildew, which diseases often prevent the later flowers from bearing pods or seed. But the haulm of beans sown in rows is decidedly inferior to that of those sown broadcast; the lower part of the stems becomes hard and ligneous, and the leaves are more apt to fall. But the loss thus experienced bears no comparison to the increase of produce in grain; besides, it may, in a great measure, be avoided by training the plants a little earlier.

The cultivation bestowed on a bean crop keeps the soil clear and loose during that period; and when the plants come up they overshadow it. By this means it is perfectly prepared for the next crop; and after the beans have been gathered in, requires comparatively little tillage. The extirpator is the best instrument which can be made use of for the purpose of leveling land which has been thrown into ridges by drilled crops. When this has been used, one plowing will suffice to prepare the land.

When beans are sown broadcast, they are usually mixed with either peas or vetches, and rarely sown alone on account of their success being so very casual.

This plant is extremely subject to attacks of rust or mildew, or both. The former shows itself on the leaves, the tips of which turn brown; this spreads, becomes darker, and finally destroys both the leaves and the plant. Mildew attacks the tops of the plants, and is immediately followed by the appearance of an innumerable quantity of black insects or bugs *(aphides)*, which soon extend themselves over the whole of the plant, and prevent it from forming any fruit. Some farmers have endeavored to diminish this evil by cutting off the tops of the plants with some sharp instrument. I have never found those crops of beans which have been sown with a drilling-machine to suffer so much from rust or mildew as those sown broadcast; for, in the former case, the plant is usually pretty strong before the disease appears, and a considerable quantity of its grain is formed; consequently, the ravages are not so sensibly felt.*

In places where the worth of the soil is known, when the bean crop promises to turn out badly, it is immediately cut and the field broken up, and the beans spread in the furrows and covered over, because a poor crop of beans would not repay the injury which they would do to the succeeding wheat crop; for it is well known that it is only those bean crops which succeed well, that form a good preparation for wheat, and that this grain almost invariably fails when sown after a poor crop of beans.

Beans should be got in as soon as the greater part of the pods turn black, and without regard to the maturity of those which were set last. A very clever English agriculturist has even gone so far as to recommend that the beans should be cut as soon as the seed is completely formed, tied up, carried to some place, and there left to ripen, in order that the land on which they grew may be the sooner plowed up. Beans sown by broadcast are frequently cut down with a scythe, and then collected and carried out of the field; but a sickle is often made use of. Beans which have been drilled in rows, and especially such as have been well hoed, can only be cut with a sickle; a scythe would break the lower pods, and the beans would then fall into the deep furrows which the hoe had left between the rows, and thus be lost. The best plan appears to me to be to have them pulled up; but this cannot be done on tenacious soils, at least not without great difficulty.

After the beans have been cut they are tied up in small sheaves, five, six, or seven of which are set up one against the other: when the bean harvest is not succeeded by very dry, warm weather, it frequently takes a long time to dry thoroughly. But as it is now well known that it is of the utmost importance that the field should be cleared with as little delay as possible, the beans are often carried to some other place to complete the process of drying.

The produce of beans sown broadcast is even more casual than that of peas. Where the ground is adapted for them, and the plants are sown in rows, and subsequently cultivated with a horse-hoe, from ten to twelve bushels of grain per acre may be expected. In Kent, and other counties of England in which beans are sown, from eighteen to twenty-seven bushels per acre of our measure is regarded as the ordinary amount of produce.

A bushel of beans weighs from a hundred to a hundred and three pounds. They contain a large proportion of nutritious vegeto-animal matter, although not so much as peas; but a larger quantity of amidon. In many places they are baked, and employed as food; sometimes they are even mixed with flour, and made into bread; and many assert that they communicate a most agreeable flavor to the bread thus formed: but this pulse is chiefly given to horses. In many parts of Germany, beans sown broadcast are kept expressly for this purpose, without being threshed; and the sheaves are cut up with the chopped straw, expressly to be given to horses. In England beans are regarded as the best of all kinds of fodder, not only for draught, but also for race-horses. They must not, however, be steeped in water, as some persons are too much in the

* With us, the aphides begin to show themselves on the leaves about the 20th of May. At this period the crop should be carefully looked over every day; and if a few lice are perceptible, which usually precede the insects by a few days, women and children should be immediately sent into the field to nip off the top of every bean plant, and carry it away. Where these laborers make use of both hands at once, the work may very soon be done, and at very trifling expense. Every thing else must be set aside in order to attend to this, for the loss of a day or two might cause the destruction of the whole crop. I have always found the flowers of plants which had been thus cropped to set better than any others. [*French Trans.*

habit of doing, in order to swell them out, but given in their natural state. They are also made use of for the purpose of fattening pigs, and are exceedingly adapted for this; but then they should be soaked in water.

Bean straw is usually considered to be very nutritious, especially when it has not suffered from the effects of unfavorable weather; this, however, depends very much upon the period at which the crop is cut, upon whether it was cut while the haulm was yet green, or later in the season; thus, in the latter case, the leaves will have fallen off, and the stems become hardened. In the former case, bean straw is considered as equal to hay, and is given to horses and sheep as such. With regard to the straw of drilled beans, as I have before stated, it often loses its quality. In this kind of produce the relative proportion of the quantity of straw to that of grain is almost always opposite.

VETCHES. COMMON VETCH (VICIA SATIVA).

Among the numerous family of vetches there are various kinds which are doubtless useful; hitherto, however, none have been much cultivated excepting the common vetch, the Narbonne vetch (*vicia Narbonensis*). The cultivation bestowed on the latter in no way differs from that bestowed on the former; and as it appears to be in no way superior to the other, excepting in cases where it is wished to cultivate vetches on very rich land, it is but little grown. After several experiments I have given up the saw-leaved vetch (*vicia serratifolia*), on account of its not having come up to my expectations.

There are several varieties of the common vetch. We have a small one which ripens very early, and one, the haulm of which is larger, which ripens late, and requires to be sown very early in the year to ensure its arriving at maturity.

The English autumnal vetch is probably the same as this large variety, but has by cultivation become habituated to passing the winter in the ground. Several experiments which have been made in our climate seem to demonstrate that this vetch is incapable of resisting the winter: it is less liable to be destroyed by sudden hoar-frosts, than by late frosts which occur after vegetation has commenced. It not unfrequently happens that even in England it is destroyed by frost: thus the advantage which might be derived from that naturalization of this species would not be very great, since it seldom ripens more than ten days before the spring vetch, when this latter has been sown in good time.

Vetches require a clayey soil, where the land contains more than sixty parts in a hundred of sand, and is not in a very damp situation; this plant will also thrive, provided that the ground is properly ameliorated, and the summer moist; but in dry summers it rarely succeeds.

It does not absolutely require a very rich soil; nevertheless, it always succeeds better, and the haulm is finer, when the soil contains a considerable portion of succulency; it is on this account that wherever it is practicable they manure for this crop.

This plant is now almost as often cultivated for its haulm as for its seed, which former is either used as green meat or reduced to dry fodder; it is cut while in flower, and before many pods are formed.

The cultivation of this crop is in no way distinguished from that of peas; as the seed is smaller, twelve metzen is sufficient for an acre of ground. In order to ensure its attaining maturity, the large vetch ought to be sown at the beginning of April. The small variety will ripen, even when not sown till the end of May; but most agriculturists recommend that the common variety should be sown early. I have, however, observed these crops for some years past, and have always found that where this kind of vetch had not been sown until toward the middle of May, it always succeeded better than when sown earlier. If cold weather comes on, the vegetation of the plants is checked, and then they are very frequently attacked by a worm, which gnaws the buds, and does so much mischief that, if the soil is at all impoverished, the plants never flower; where, however, it is rich, the plants occasionally overcome this evil, and shoot up again. Those vetches which are sown later escape the attacks of this worm, the period of its existence being short.

Where it is intended to use vetches as green fodder, or reduce the crop to hay before it has attained its maturity, it may be sown in any weather up to the beginning of July. In order to be enabled to stall feed cattle on green vetches, a certain quantity must be sown which will last until the others come up. When intended for this purpose, the vetches are usually mingled with spring rye, barley, or oats; and to these latter is often added buckwheat, in order to render the mixture thicker and richer. When the crop is to be made into hay, it is considered most desirable to sow the vetches by themselves, as it then dries more uniformly. This crop is made into hay in the same manner as clover or lucerne; consequently I shall refer my readers to the directions which will be given when I come to speak of the haymaking of these crops. Vetches take longer drying than clover, but are not so liable to be spoiled when the process of drying is not properly conducted.

When vetches are intended for the feeding of horned cattle, in the shape of green meat or dry fodder, they are mown while in full flower; but when they are intended for horses, the pods are suffered to develop themselves a little, because the quantity of fodder is thus increased, and the vetches rendered more nutritious.

The sooner vetches are mown the less do they impoverish the soil. But whenever this plant has been sown, the ground must be broken up directly the crop has been got in; the importance of this course is so generally known and recognized, that all persons who have it in their power, cause the newly mown plants to be immediately conveyed to some other place to be dried.

When vetches are mown early in the season, and at the time when they are putting forth their first buds, they will shoot again if the soil is rich; but where it is poor, nothing is gained by such a proceeding; on the contrary, the two cuttings together do not amount to as much as would have been obtained from one good crop cut at the usual period.

It is a very bad practice to endeavor to derive advantage from the second shooting of vetches by pasturing cattle on them, as the soil is then hardened by the feet of the animals, and the succeeding crop is thus often seriously injured. Occasionally a second crop of vetches is sown on land which has produced one that has been mown while green; but in order to do this the utmost promptitude is necessary, and not a moment must be lost between the gathering of one crop and the sowing of the other. But, in general, buckwheat or radishes are sown after vetches which have been cut while green.

The produce of vetches in seed is very unequal. Sometimes as much as twenty-four bushels per acre have been obtained; but eight bushels may be regarded as the average quantity. Vetches grown on rich land have yielded as much as from 1,800 to 2,000 lbs. of straw, comprehending the husks and refuse. The haulm of this crop is preferred to pea haulm for the purpose of feeding cattle. When vetches are cut while green, and at the period when their pods are just beginning to form, 3,000 lbs. of straw per acre are often obtained; but even where the soil is most fertile, it is safest only to reckon on 2,000 lbs. When on account of the spring being very dry the vetches do not succeed, the produce will fall to 1,000 lbs. per acre.

Numerous experiments seem to testify, that when cut while green, vetches scarcely deprive the soil of any portion of its fertility, but that, on the contrary, the succeeding crop has often been found to be decidedly better than one which followed a dead fallow, provided, however, that the ground has been broken up without loss of time after the gathering of the vetches. Vetches which attain maturity, and yield a produce in grain, may, in that respect, be compared with peas. The common mixture of vetches and oats, when suffered to attain maturity, exhausts land much more; and a crop of rye grown on a field which has produced this kind of fodder, and from which it has been mown little by little, as it was required, will indicate very plainly by the difference in its produce which were the spots on which the vetches and oats were suffered to stand too long. In England it is by no means unusual to sow vetches solely for the purpose of ameliorating the soil. In such cases, however, this crop is not plowed in at once, but cattle intended for fattening, and pigs, are turned on to it; which animals certainly spoil a great deal by trampling it down, but they also consume a great deal. After this the land is broken up without loss of time, and sown with rape. This mode of proceeding is not in some respects so little economical as it appeared to be to a traveler with whom I am acquainted.

When vetches have been left standing till their seed is ripe, they are commonly used to feed horses and fatten pigs; they are also given to sheep, and for this purpose are considered preferable to peas. The seed of this plant is rarely a marketable commodity; it is, however, not unfrequently sold for sowing. Vetches may be kept for a long time, and ultimately sold at a price which yields large interest. In agricultural undertakings in which the production of fodder forms an essential feature, it is advisable to keep a supply of vetch seed in the granary, because this plant furnishes the best resource when the crop of clover fails.

The straw of vetches which have perfected their seed is more grateful to cattle than that of peas; it is often, indeed, considered equal in value to hay; but it is not to be compared with vetches that have been mown in the green state and made into dry fodder.

There are a few other sorts of pulse rarely met with, and confined to certain localities; such are the Spanish lentil *(lathirus sativus)*, and the chick-pea *(cicer arietinum)*. The cultivation of these plants differs in no respect from that of peas and vetches, and hitherto I have heard no reason assigned for preferring them to the plants already noticed.

BUCKWHEAT (POLYGONUM FAGOPYRUM).

This plant thrives well on soils which are too poor for all other kinds of grain either of the spring or summer varieties. It grows on dry, sandy soils, provided only that the drouth be not felt precisely at the time when the plant stands most in need of moisture; it then yields as plentiful a crop as any other kind of grain; but if the ground be in a situation somewhat more accessible to moisture, the crop of buckwheat is so much the more to be depended upon. This plant also thrives on heath and marsh lands, provided that the latter have been previously drained. It is cultivated to great advantage on clearings of this description, and is very useful in preparing the soil for the reception of other kinds of grain.

In sandy districts buckwheat is the only crop which succeeds when sown alternately with rye; in such situations it takes the place of all other fallow crops: it is also sown on lands where rye has been grown. It, however, thrives better as a fallow crop on land which has been used as pasturage, or left in repose for a few years.

On richer soils the plant grows more vigorously, but only in the haulm, rarely producing so much seed as when grown on proper soils. A small quantity of manure is advantageous to it; but a large quantity makes it grow too strong in the haulm. When the land on which buckwheat is to be grown requires manuring, it is usual to give it only half the usual quantity, the remainder being reserved till after the harvest.

Manure furnished by furze, a plant which is always abundant in districts where buckwheat is grown, is particularly well adapted to this kind of grain.

The sowing of buckwheat even on the lightest soils, must always be preceded by two plowings, in order to destroy the weeds.

This plant, which was brought from the East at the time of the crusades, has not yet lost its sensibility to cold; the slightest hoar-frost destroys it. The sowing must therefore be deferred till all danger of cold nights is over. I have, however, known buckwheat to be destroyed by frost as late as St. John's day. It should not, therefore, be sown earlier than the middle of May, or later than the middle of June;* for, if sown at a later part of the season, it will be liable to be

* Throughout at least the half of France, in the South of Switzerland, and generally in countries where the corn is housed about the middle of July, and the hoar-frosts seldom begin before the 24th of October,

attacked by the white frosts of autumn before its seed is ripe, and then the quantity of grain will be much diminished. The quantity of seed sown on a given extent of ground is about the half of that used in sowing wheat: sowing more thickly is injurious to buckwheat. In countries where this plant is sown in large quantities, they treat it as if it said to them, "Make room for me, I am coming up."

The success of buckwheat is remarkably affected by the weather to which it is exposed in the several stages of its growth; in this respect it is more susceptible than any other kind of grain. It requires dry weather immediately after sowing, and springs up during the time of greatest drouth; but after putting forth its third leaf, it requires rain in order that its leaves may be developed before the appearance of the flower, which soon follows. During the long time for which it continues in flower, this plant requires alternate rain and sunshine to facilitate its growth and enable the flowers to set. The flowers drop off during thunder storms, or even on the occurrence of electric phenomena unaccompanied by rain. Buckwheat is also incapable of withstanding violent easterly winds, which cause it to wither before its flowers are set. After flowering, the plant again requires dry weather to bring all its seed to maturity at the same time, and ensure an early harvest.

The success of buckwheat is, therefore, very precarious. It depends not only on the general state of the weather throughout the season, but also on the particular time which may have been chosen for sowing. A week earlier or later often makes a very great difference. Hence those who wish to make sure of their crop of buckwheat sow it in three or four separate portions, and at different times.

The seed should be simply covered up with the harrow, and not in furrows. I have also found that the use of the roller is injurious.

The ripening of the grain is very unequal; for the plant is continually flowering and setting. We must, therefore, cut it at the time when the greatest quantity of grain is ripe. It sometimes happens that the first flowers do not set, or that they produce nothing but barren seeds, destitute of farina, while those which come out later yield better seed. But the grain will ripen, and even the flowers set, while the crop is lying on the ground after cutting, especially if rain fall. This occurrence is, therefore, considered favorable.

The produce of buckwheat is, as just observed, very uncertain. When it is sown after a corn crop, one good harvest may be expected in about seven years; in the same interval we may reckon upon three medium and three bad harvests. But when buckwheat is sown on land which has been left in repose, or laid down to grass for a few years, we may reckon upon one good crop out of two. Extraordinary crops, amounting to twenty bushels per acre, are but very rarely obtained.

In many countries, buckwheat furnishes an important article of food for man; and, when cheap, is also used to fatten cattle and feed horses. Its price falls very low in years of plenty, but rises again in seasons of scarcity. Cultivators who have the means of keeping it often lay it up in store; it is well adapted for this purpose.

The straw of buckwheat is much esteemed; it is nourishing and wholesome for cattle of all kinds. It should, however, be consumed before Christmas.

Indispensable as this plant may appear in some countries, its cultivation for grain is so precarious in others, that we can scarcely venture to recommend it. As a fodder plant, however, it is excellent; and, when cultivated for this purpose, may be depended upon as well as any other plant. We may sow it as late as we please; the haulm is sure to be good, provided only that there be no danger of frost, and that the soil contain a moderate quantity of moisture. It may either be given to cattle as green-meat, or else made into hay. It dries but slowly, but does not spoil when left on the ground without being turned. When treated by Klapmeyer's method, it is likely to turn out very good.

The cultivator who wishes to raise it for this latter purpose should choose a year in which the plant has been particularly successful, in order to obtain a good supply of seed; this, he will find, will yield him as good a return as any other. Buckwheat raised for this purpose may be sown on the stubble of a corn crop; or still better after vetches which have been mown early in the season to be consumed as green-meat.

A mode of proceeding which I have found perfectly successful is, to sow buckwheat in July, together with St. John's day rye; then to mow the buckwheat in the green state, and reap the rye, when the grain is ripe, the following year. This may be done very advantageously on land which has borne a crop of vetches cut in the green state. Radishes may also be sown among buckwheat.

This plant is also well adapted for sowing, as a preservative crop, either with clover, or, still better, with lucerne. We shall have occasion to recur to this matter.

The produce of buckwheat as a fodder-plant is, however, very different, according to the circumstances under which it is grown. I have obtained crops of it, exceeding in weight those of vetches grown on the same soil, and to all appearance by no means inferior in nutritive power.

Some persons recommend a kind of buckwheat known by the name of Siberian buckwheat (*polygonum Tartaricum*). This variety has the advantage of passing the winter under ground. Two crops may, indeed, be obtained from it; but, after repeated trials in the open field, I have found its produce so insignificant, and the crop, especially in the second year, so infested with weeds, that I cannot, by any means, acquiesce in the elaborate praises which others bestow upon it. In gardens, where it can be weeded, its growth is doubtless very fine.

buckwheat may be successfully cultivated as a second crop, after wheat or rye. In these countries the corn is carried, and the land plowed up with all possible speed; the seed is then sown after one plowing, and carefully covered up with the harrow. This plant remains in the ground for ten weeks, or three months, from seed time to harvest. [*French Trans.*

MESLIN.—MIXTURES OF DIFFERENT KINDS OF GRAIN.

In many countries it is customary to associate different kinds of grain, and likewise different sorts of legumes; and even to cultivate grain and leguminous plants together. Many practical cultivators say that they have obtained a more abundant produce by this method than by the separate cultivation of the same kinds of grain. This assertion is certainly not without foundation: I have frequently made experiments, which remove all doubt of its correctness. It often happens that the seeds of both the plants which have been sown together thrive equally well, and the quantities of the two plants contained in the crop are in proportion to the quantities of the respective seeds. At other times one kind will succeed remarkably well, and almost choke the other; in such a case the quantities of the two plants in the crop are by no means proportioned to those of the two kinds of seed: this is particularly the case when the state of the weather has been peculiarly congenial to one or other of the associated plants. In such case there is this decided advantage, that when the weather is unfavorable to one of the plants it is by so much the more congenial to the other; the latter consequently grows more vigorously, and obtains a better supply of nourishment on the ground which it has won by the failure of its companion; moreover, it cannot be denied that certain plants absorb substances which are not adapted for the support of others.

It must, however, be understood that plants thus associated must be such as ripen about the same time. If the seasons of their maturity are not exactly the same, the crop must be gathered when the plant which grows the more vigorously or ripens the more quickly of the two has attained that stage; in such a case the other will perhaps ripen after it has been cut down, or it may be useful although it has not attained its full maturity. Many mixtures of this nature may be separated by the sieve, or by the operation of *fanning;* but the seeds are commonly used together.

It has, however, been observed with some reason that mixtures of this nature are peculiarly trying to the soil, although at the same time it must be admitted that they yield an abundant supply of straw for the production of manure. It is said that the cultivation of different plants together preserves the soil from weeds; this may be true in certain cases.

The most usual mixture is that of wheat and rye; known by the name of *meslin*. This mixture is very common in some countries, more so indeed than pure rye. It is used to make ordinary bread, which is said to be particularly nutritious and agreeable to the palate. In the Netherlands, on soils no longer fit for the growth of wheat, this kind of cereal produce mixed with rye is said to yield more than it would if grown by itself; and, moreover, not to diminish the quantity of rye in the crop. Meslin is usually sown after a crop of wheat. In other countries spelt is mixed with rye instead of wheat; these two kinds of grain are easily separated.

Flat barley and oats are also grown together; and, from my own experiments, I should say that they are well adapted for this purpose. If the soil be favorable to barley, this plant growing more vigorously will choke the other to a certain extent, if at least the weather be somewhat favorable; in the contrary case, the oats being the more hardy of the two will usurp the place of the barley, and when threshed will yield perhaps four times as much as the latter. Whenever I have grown these two plants together I have obtained better crops, as regards both weight and value, than from barley and oats separately cultivated and reaped. I must, however, confess that I have never made the experiment on a soil peculiarly well suited to the former of these plants. Some persons add spring-rye to this mixture when grown on light soils.

Among the mixtures of grain with leguminous plants, the most common is that of oats and vetches. They are frequently cut with the chaff-cutter without being previously threshed, not only when they are left to ripen and used as fodder for the cattle, but also when they are mown while green and given to the cattle in that state, or else made into hay. Vetches find better support when grown with oats, than when alone. Barley and spring wheat are also mixed with them.

It is not unusual to sow peas in small quantities among spring-wheat; it is said that the quantity of wheat is not thereby diminished, and that the peas are obtained in addition. This proceeding is usually resorted to on soils on which it is not thought safe to venture upon the cultivation of peas. On sandy soils, peas are associated with spring rye. The peas thrive when scattered among these grain crops, which they would not do if they were alone. By the use of the fan, the peas may easily be separated from the corn.

On calcareous, clayey, and meager soils, especially on declivities, it is usual to sow beans among a crop of oats. In many countries it is not uncommon to meet with a mixture of beans, vetches, beans, and oats, sown at random on the fallow of a rich soil. This mixture produces a close mixed crop of plants, which, being supported by the beans, maintain their erect position, and yield a larger quantity of fodder than any other plant that can be sown for this purpose. The crop is rarely allowed to ripen, but is cut as soon as the seed is formed. It is not threshed; or, if this operation is performed, it is done very lightly, to separate the ripe seed, and the straw is chopped up and used to feed cattle. It is with this kind of food that horses are entirely fed in some countries: it frequently goes by the name of *beans*. The relative quantity of each kind of seed to be sown for this mixture is determined by the nature of the soil. In argillaceous soils the quantity of bean-seed sown is the greatest; in soils of a lighter nature, more vetches are used.

Vetches are also mixed with buckwheat, especially when the crop is to be cut in the green state.

CULTURE OF HOED OR WEEDED CROPS.

This denomination includes a great number of plants, which, though they belong to different classes as regards both their nature and uses, and in a botanical as well as in an economical point of view, may yet be classed together, as far as their mode of cultivation is concerned. To avoid the necessity of repeating the same details in what we shall have to say upon the cultivation of each of these plants, it will be proper to begin by describing the various operations belonging to this department of cultivation, and the implements with which they are executed.

In the latter stages of their growth, these plants require a much greater space than that which

they occupy on first coming up; they must, therefore, be sown or planted with proper distances between them. But the intervening spaces would be occupied by weeds, which would soon choke the crop, or at least deprive it of its due supply of nutriment, if after the sowing or planting both soil and crop were left to Nature. Now, to have all these weeds pulled up by hand would not only be too costly, but, moreover, would not fulfil another condition which ought to be kept in view, viz., that of lightening the soil and preparing it for subsequently affording nourishment to the plants. Consequently, since the time when these plants were first cultivated, particularly in gardens, it has been thought necessary to raise and lighten the soil with hand-hoes and mattocks of various kinds, by means of which the light soil is heaped up around the plants as they grow. The complete and proper performance of this cultivation, and its frequent repetition, have always been regarded as essential to the success of the crops of which we are speaking.

But these operations, if executed by manual labor, would require so many hands, that the raising of such crops on a large scale and in the open field would be impracticable. Nevertheless, as the advantages of this mode of tillage became obvious, and especially as the cultivation of potatoes became more and more extended, cultivators began to employ in its execution the binot and other implements of the plow-construction which they had at their disposal. Many cultivators made modifications in the binot to adapt it to these operations. My own alterations in the Mecklenberg binot, as described in my edition of Bergen's work on the management of cattle, having been approved of, the instrument thus modified got into general use under the name of the "potato-hoe."—I have since improved it, particularly by shortening the trace-bar, and rendering it more independent of the team, so that the machine is more under the power of the driver. I have since found it advantageous to do away with the iron point which was placed in front to enable the instrument to penetrate the soil, and to substitute for it a broader and less pointed share, by means of which a greater quantity of mould is raised out of the furrow and turned over on its sides.

This machine has also been furnished with movable mould-boards, which, by means of a regulator, may be separated to a greater or less distance at their hinder extremity: they are made of cast-iron. No particular instructions are necessary with regard to this matter; the machine having met with general approbation, I have been unwilling to render it more complicated for fear of hindering its general adoption.

The English implement known by the name of the "double mould-board plow," is still better adapted for the operation of earthing up. It raises and heaps up a greater quantity of mould, makes deeper furrows, and, when its mould-boards are separated to a greater distance at the back, it is more effective in tearing up weeds which attach themselves to it. The cultivation of hoed crops may, by the aid of this machine, be executed with a degree of perfection unattainable before its invention.

This instrument is, however, rarely used for the first performance of the operation of earthing up, partly because there is no necessity for executing this labor very completely at first, and partly because the machine requires two horses to draw it; whereas the light horse-hoe previously mentioned requires but one.

But there are many plants which require cultivation before earthing up, not only that they may be freed from weeds, but also that the earth which is to be laid up to them may be previously lightened, pulverized, and aerated, and its nutritive parts rendered more soluble. For these purposes a swing-plow is sometimes used to remove the earth which lies close to the plants, and turn it over toward the middle of the space between the rows. In this operation the plow is passed with its flat side as close to the rows as is possible, without injuring the roots of the plants. To obviate the dangers of uncovering these roots, the operation is at first performed on one side only, and five or six days after on the other; there is thus formed a ridge of light soil in the middle of the intervening space. After the ridge has remained in this state for a certain time, it is again turned up with the double mould-board plow, which throws it once more against the plants; these plants can then extend their roots into the freshly turned-up soil.

Whatever may be the efficacy of this operation when properly performed, we cannot deny that it is attended with great difficulties; particularly that it requires skillful plowmen and a judicious selection of the time for its performance; for which reasons, especially if the soil be moist and tenacious, and the weather unfavorable, it is very delicate, and demands on the part of the operator a certain practical tact and a considerable degree of attention, without which it may easily be converted into a source of injury. Besides this, it cannot well be resorted to when the distance between the rows falls short of two feet; and as the soil requires to be removed at different times from the two sides of the rows, the operation likewise takes up the double time.

The destruction of weeds, and the lightening of the superficial stratum of the soil, may be effected in a manner less complete, perhaps, but sufficient in most cases, and much more easy of execution, by the use of implements which merely scarify the soil, but at the same time bruise and pulverize it. Various implements of this kind are in use.

If it be thought sufficient to rake up the weeds and merely scarify the soil, flat shares are to be used; but if it be necessary to turn up the soil to a greater depth, and pulverize it, the shares must be convex, and the plow deeper. The former method is adopted when the plants are young, in order to avoid the risk of burying them under the mould.

There is also used for this purpose and inplement furnished with a large rake, or sometimes a scraper, similar to that which is used for raking garden walks. In case of necessity, such an instrument may be drawn by men.

Lastly, a common swing-plow, furnished with a two-edged share, but no mould-board, may also be used for this purpose.

These machines have received almost innumerable modifications, and have been designated by a corresponding variety of names; but there is no essential difference between them. They all require to be modified according to the stiffness of the soil and the state of growth of the plants which are to be cultivated by them. For this purpose different pieces of iron may be fitted to the same frame-work; but, as the frequent shifting of the iron-work is trying to the instrument, and

occasions loss of time, I think it better, at all events when the extent of ground to be cultivated is somewhat considerable, to have a number of these implements ready for use.

Cultivation with implements of this description bears the same relation to that which is performed by manual labor that plowing bears to spade cultivation. The use of cultivators or horse-hoes of various kinds can alone render the raising of hoed crops practicable on the large scale in the greater number of agricultural undertakings. With one horse and an experienced driver, seven acres per day may be cultivated without extraordinary effort, provided the horse be well trained to the work; for, since the horse-hoe is drawn over three plow-furrows at once, the extent of ground which the horse and driver have to go over in cultivating these seven acres is not greater than that traversed by the plow in plowing two acres and one-third, and the force which a horse exerts by drawing either the small horse-hoe, or the horse-scraper or rake, is scarcely equal to that of one of the pair employed to draw a plow. Frequently, however, only five acres are cultivated in a day; but this is certainly the minimum. As this operation requires to be executed with a certain degree of circumspection, the driver ought not to be hurried for fear that he should spoil his work by endeavoring to do it too quickly. Moreover, the quickness with which cultivation with the horse-hoe can be executed, depends, as in plowing, on the length of the furrows, and the necessity of turning more or less frequently. If the men and horses are not accustomed to the work, or if the plants are not sown in straight lines, it is better to employ two men, one to guide the horse, and the other the machine. If a slightly-made and clever lad can be employed in the work, it is best to let him mount the horse, because he then sees better before him, and can guide the animal with greater facility. If the machine be made to pass a second time in the same direction, the conductor may be dispensed with, for the horse is sure to follow the track already made. For the large plow used for earthing up, especially if it be required to cut deeply into the ground, two horses are, however, required: they may be harnessed to it by means of a trace-bar long enough to enable the two horses to walk in the furrows on either side of that in which the plow is at work.

The smallest amount of work that this machine will perform is equal to that of forty laborers; for, in order to do the work at the same rate, at least eight laborers per acre would be required.

In the cultivation of weeded crops, it is often of less importance to obtain the greatest quantity of produce that a given extent of ground is capable of yielding, than to obtain the quantity which is absolutely wanted at the smallest possible expense. The rent of land is much less than the cost of labor, and as these crops are intended to take the place of the fallow, and answer the same purpose, they ought not to be charged with the ground-rent. If I get 200 quintals from an acre of ground, at an expense of twelve rix-dollars, and 50 quintals at a cost of only three rix-dollars, the advantage may very possibly be on the side of the latter, especially if I have plenty of ground ready for use, and requiring this kind of cultivation, but scarcely a sufficient number of laborers for sowing and cultivating a larger extent of surface. Plants sown with tolerably wide spaces between them may be cultivated much more effectually than those which are very crowded.

It is absolutely necessary that all weeds appearing above ground be utterly destroyed a short time before the planting or drilling of the vegetables of which we are speaking, in order that there may be no necessity for raking or hoeing before the plants have acquired a certain degree of strength. The soil must of course be previously well prepared with the plow, but, after the last plowing, it is advisable to level the surface with the harrow, then, in dry weather, to pulverize the clods with the roller, and harrow again with considerable force. By this treatment the weeds are made to germinate quickly; and when their germination has taken place, the sowing or planting is preceded by cultivation with the extirpator, after which the ground is again harrowed. Even if the reäppearance of weeds cannot be entirely prevented by these precautions, it is at all events retarded, and the quantity of the weeds diminished, so that in many cases the use of the rake may be dispensed with, and the operation of earthing up proceeded with at once. The cost of these preparatory labors is largely repaid by the saving which they effect in the after cultivation.

An implement of the greatest utility in the raising hoed crops, is the furrower, or marking-plow; which, however, ought to furrow more deeply than the instruments of this name in common use. It may be made of iron, or of wood covered either with iron plate or with cast iron, as recommended by Fellenberg. With this implement lines are traced in a certain direction; and by means of a cord stretched across, the exact place is marked which each of the plants is to occupy. In order to vary the distance between the rows, we must either employ another instrument, the feet of which are placed at the required distance, or have the former made with movable feet, so that the distance between them may be modified according to circumstances. In the small furrows made by this machine, the plants are arranged in parallel lines, and at the same time sown rather more deeply than they otherwise would be. They are thus, to a certain extent, protected against drouth, enabled to absorb a greater quantity of moisture, and ultimately covered by a greater quantity of light soil. When the seed is small, it is deposited in these furrows, either by hand or with the drilling machine; but the furrows must be made immediately before the sowing, in order that the soil in them may remain fresh and light.

For weeded crops which are sown far apart, and raised from seed on the spot on which they are to attain their full growth, it is usual to employ simpler drills, which sow but one row at a time. Machines of this kind have been invented for sowing two or three rows at once. No advantage has, however, been derived from them; on the contrary, they have been found inconvenient from not admitting of any alteration of distance between the rows, according to the nature of the crop and the fertility of the soil.

When seed-beds are formed, from which the plants are to be removed after a time and transplanted to the ground on which they are to attain their full growth, the seed is either spread uniformly or sown in close furrows, in order to increase the facility of destroying the weeds which grow up with it.

If we have made up our minds to cultivate these vegetables, and chosen and prepared the land on which they are to grow, it is very annoying to find ourselves short of plants. It is, therefore, of the utmost importance to provide good seed: to raise it, as far as possible, ourselves; or, at all events, to purchase it of cultivators upon whom we can depend, and not of seedsmen, who are often themselves deceived in its quality. But it sometimes happens that, though we have used the best seed, still the seed-beds are deficient. Plant-lice (aphides) are very destructive to the plants, especially to those of the radish and cabbage tribe, at the time of their germination. When the weather is warm, there is, perhaps, no better method than to cover the beds with boughs of trees, place straw upon them, to the thickness of about an inch, and keep it constantly moist until the plants shall have put forth their fourth leaves; after that, the insects may, indeed, attack the plants, but they will not easily destroy them.

It is absolutely necessary to select for the seed-beds a soil well prepared, *between the wet and the dry*; not recently manured, but yet rich and fertile.

There are some plants that should be sown as early as possible. They may be protected from frost, occurring in the latter part of the season, by the coverings above-mentioned. Hot-beds are certainly very convenient, but they can scarcely be used on the large scale. The more there is to be apprehended from plant-lice, the earlier should the seed be sown, in order that a second or third sowing may take place, if required. A supply of seed should always be kept for this purpose.

On the average, we may reckon that, to produce plants sufficient to cover an acre of ground, the extent of the seed-bed must be four square perches. Sometimes, indeed, this extent of ground yields a superabundance of plants; but the waste is very trifling, since these plants may be set in other situations, or even used as green-meat.

If we take the trouble to pull up the weeds out of the seed-bed, we obtain more healthy plants as the reward of our labor. I have often contented myself with mowing down the weeds which grew more vigorously than the plants of the seed-bed; and, in my opinion, this method is sufficient.

When the seedlings have attained a due degree of vigor and hardihood in the seed-bed, they should be transplanted as soon as possible, to prevent their stems from growing too long. If the weather be mild and damp at the time of transplanting, the labor and difficulty of the operation are greatly diminished. All the available hands must then be employed upon it, in order to take advantage of this state of the weather: it is even advantageous to engage as many additional laborers as possible, in order that the transplanting may be promptly executed. The cost of this labor is much diminished by properly dividing it, so that each man may perform his part without delaying or hindering the others. It is true that strict surveillance is required for the attainment of this object; but it is better to institute this superintendence, and have the work quickly executed, than to allow it to be uselessly protracted for want of proper management. A certain number of men should be employed to take the plants out of the seed-bed. If the soil be hardened, though in ever so slight a degree, the plants must not be forcibly torn up; but the earth around them must be loosened with a spade, and thrown on one side, so that they may be taken up with care, and without injury to the fine filaments of their roots. A bucket is then to be filled with a semi-fluid composition, consisting of marly clay, which mixes readily with water, cow-dung, or fermented dung-water, and a quantity of water just sufficient to give the mixture such a degree of consistence that when the roots of the plants have been immersed in it, these roots and their most delicate filaments may remain coated, and, as it were, completely enveloped by it. The next thing to be done is to take a handful of plants, and, after having cut off the ends of the leaves, to plunge the roots in the semi-fluid mixture; these plants are then to be placed handful after handful in a basket, and carried to the field on which they are to be planted. This mode of covering up the roots is both simple and effectual; it completely protects the plants against the injurious action of the air, keeps them moist, and provides a proper quantity of nutriment for the most delicate filaments of their roots. Plants thus prepared may without injury be left out of the ground for several days, if they are to be carried to a place at some distance off: it is, however, undoubtedly better to plant them immediately. If the ground be moist, and the sky overcast, the plants which have been put into the ground will not require watering, but will remain standing without it; and thus a great deal of trouble will be saved.

The number of persons employed to carry the plants to the field must be regulated according to the extent and distance of the plantation. These persons may, on arriving at the field, distribute the plants to those who are occupied in setting them: or there may be a man specially employed in carrying the plants from the basket, and distributing them as they are wanted.

In the plantation itself, the labor may be divided between those who make the holes in the places indicated by the marking-plow, and trim the plant by again thrusting their dibbles into the ground, and pressing the mould against the roots, and those who place the plants in the holes. But it is necessary that the laborers should be well practiced in the work, that they may not hinder or delay one another: otherwise it is preferable to let the same man make the holes, and put the plants in them. Each laborer, or each pair of laborers, is employed on one row only at a time, unless the plantation is to be very thick: in that case each takes two rows. The laborers work bias, following one another both in going down the field and in returning: they should always be kept as much as possible in these relative positions.

It is usual to make the holes and trim the plants with a wooden dibble, furnished with a proper handle: but it is better to use an iron tool, by which, if a little expertness be acquired in using it, the operation of the planting is greatly facilitated. The planter cultivates the soil with it: he shifts the instrument a little from its place, introduces the plant into the hole, stirs the mould around it to enable it to slip into the hole, and again thrusts his dibble into the ground, so as to press the earth against the roots without injuring them. If the laborers are unskillful at this operation, it is doubtless better to fit the dibble with a straight handle, having at the top a little cross-piece on which the workmen can lean, in order to thrust the implement more firmly into the ground. The

soil is not so much hardened by this instrument, as it would be by a round piece of wood.

If the soil is dry, the weather warm, and the sun powerful, no time must be lost in watering the plants after they have been placed in the ground: the water for this purpose is carried to the plantation in bucking-tubs. In such a state of the weather it is advisable not to plant in the early part of the day.

Even when the planting has succeeded as well as can possibly be expected, there will always be a deficiency of a few plants, arising from their not having taken root, or having been destroyed by accident. As soon as this deficiency is perceived, fresh plants must be put into the ground with all possible expedition; for, if this operation be delayed, the plants afterward introduced to fill the vacant spaces will not grow to the same hight as the others, but will, on the contrary, be choked by them. Sometimes, however, before replanting, it is advisable to rake the ground with a horse-rake, otherwise the plants recently put in might easily be buried under the earth turned up. Good and healthy plants must be kept ready for this purpose: it is useless to plant those which have been left behind on account of their weakness; they would have no chance of succeeding.

These vegetables are usually planted on unbroken and level ground, or else on ridges or lands of various widths. But it is also the practice to plant, and even to drill, on very narrow ridges previously formed by the plow. The object of this method is to supply the roots from the beginning with a thicker stratum of humus. The best mode of forming the ridges is to use the large double mould-board plow, which does the work very well. Sometimes the roller is passed lengthwise over the ridges, in order to depress their crowns a little. This mode of cultivation is often highly successful, because the roots meet with nothing but light and fertile soil to a considerable depth, and thus have more room to spread. But the difficulty of destroying weeds is at the same time increased; and it becomes necessary, either to resort to the method described at p. 444, or else to seize the moment when the greater number of weeds which show themselves at the surface of the ground have germinated and put forth their seed-leaves; and then with the same plow that has been used for forming ridges, care being taken to separate the mould-boards to a somewhat greater distance at the back, the furrows are again turned up, and the young shoots thus covered with fresh mould brought up from the bottoms of these furrows. On the tops of the ridges in the rows in which the plants grow, the weeds are soon destroyed with the hand-hoe. But if the favorable moment be allowed to pass, the removal of weeds becomes very difficult, because it then becomes scarcely possible to use either the paring-plow or the horse-rake for this purpose. I have always obtained excellent crops by this method. It is not, indeed, applicable to dry, loose soils; but, on the other hand, it is excellent for those which are moist and tenacious.

The machine for drilling at wide intervals may also be used for sowing the seed of these plants in ridges; and as the thickness of the vegetable soil is considerable, the success of the method is as great as can be wished; but the difficulty of keeping the soil free from weeds is even greater than when other methods are employed. According to my own experience, indeed, I should recommend that this method be adopted only on soils which have previously been well weeded.

It is recommended by some cultivators to place all the manure, especially when the quantity of it is insufficient, exactly under the rows, in order that the plants may derive the greatest possible quantity of nourishment from it. The method pursued is as follows:—In the first place, furrows are made with the double mould-board plow as nearly as possible in straight lines, and at equal distances. The dung is then brought in a cart drawn by one horse, but wide enough to admit of the wheels running in two furrows, one on each side of that in which the horse walks. A man following the cart draws out the dung in such a manner as to make it fall into the middle furrow in little heaps, at small distances apart, while two others spread it in the three furrows at once. The dung used for this purpose must be free from straw. When it has been thus spread out, the inter-furrows are turned up with the same plow, which is now made to enter as deeply as possible, and the dung is thus covered by the mould taken out of the new furrow. Afterward the roller is passed over the ground in the direction of the ridges in order to depress them, and the vegetables are sown or planted on them. The plants are thus set exactly over the manure.

The advantages of this method do not, however, appear to me so great as many persons assert. I prefer first to carry all the dung on to the field, and then to mix it with the vegetable soil by repeated plowings. This method, even if not more advantageous to the hoed crop which immediately follows its application, is certainly more beneficial to those which come after; and it is to these latter that attention should chiefly be directed. When the plants are earthed up, they always get access by their roots to the manure which is mixed with the vegetable soil, since the whole of this stratum is heaped up close to them. On the other hand, although this operation is not difficult, it is very tedious, and causes considerable delay. I have tried it but once, and I therefore hold my opinion subject to correction, according to the results of well-conducted experiments.

Finally, it must be remembered that all these crops require the land to be deeply plowed.

VEGETABLES FOR THE MARKET.

Many of these may, by cultivation with the horse-hoe, be raised to great advantage.

The pecuniary profit arising from the culture of *vegetables for the market* is, in some cases so extraordinary, that we cannot but wonder at the limited extent of this branch of husbandry, which is, in fact, confined to certain countries, and even there limited to particular kinds of produce. In many countries it is almost or even entirely unknown, although vegetables of this description are often very much wanted, and must be procured from foreign countries, after having passed through the hands of several traders. In many countries, in consequence of the practice of this branch of husbandry, the value of the soil or the rent of landed property seems capable of surpassing the highest rate that it has ever yet attained, even at a time when this rate would otherwise fall with the diminished price of grain. The greater the depression in the price of grain, the higher is the profit derived from these vegetables, because, when the price of corn falls, that of labor falls with it. When a naval war throws obstacles in the way of the exportation of corn, which is always the basis

of the active commerce of Germany, the price of grain falls, while the value of these vegetables rises, a circumstance which greatly increases the importance of their cultivation at such a time. It is, undoubtedly, by this description of produce that the skill and energy of the cultivator are best repaid Why, then, do not all agriculturists avail themselves of this source of profit, more especially at a time when they have so much reason, as they have had from 1809 to 1811, to complain of the low price of the more ordinary kinds of produce?

The neglect of this branch of husbandry arises, no doubt, from the various difficulties connected with it—difficulties which many cultivators know not how to conquer, and, in meeting which, they follow the example of other persons who have met with nothing but ruin in the pursuit of this branch of Agriculture.

Almost all plants of this description require a soil which is either naturally fertile, or has been greatly improved by careful tillage. They require abundance of manure for the production of which they do not, like grain and fodder-plants, afford the primary material. Hence, the agricultural circumstances of some countries are directly opposed to the practice of this branch of husbandry; which is consequently limited to particular districts, where natural fertility of soil, situation, or an improving system of tillage continued for a long series of years, has produced a superabundance of manure. When, without attending to these circumstances, a cultivator, led away by the great profit which the culture of these vegetables seemed likely to yield, has undertaken to raise them in large quantities, the profit at first arising from them has, perhaps, been enormous; but subsequently, the establishment, taken as a whole, has been exhausted and weakened to such a degree, that the final result has been decided loss. Many cultivators have realized as much as thirty or forty rix-dollars per acre net profit in this way, and have afterward been utterly ruined. The first essentials toward the raising of these vegetables in large quantities are, then, a soil in good condition, and a superabundance of manure of the kind required by the very crops which form the raw material of manures. A system of husbandry founded on the continued production of a large quantity of fodder, and the preservation of the fertility of the soil, are absolutely necessary for the safe cultivation of vegetables for the market. unless, indeed, the land be favored by Nature in an extraordinary degree. If the soil can be abundantly replenished with the substances which these plants take from it, the greater number of them will keep it clean and light, either by their own action or in consequence of the cultivation which they require; they also afford an excellent preparation for those kinds of produce which are more commonly raised in the field.

Moreover, the cultivation of vegetables for the market requires an exact knowledge of their nature, and of all circumstances connected with them. A person not possessed of this knowledge is very likely to neglect some point or other, which, at first sight may appear indifferent, but which in reality, has great influence on the success of the crops. The greater number of them must not, like cereals, be left to themselves during the time of their growth: the cultivator cannot say, when the seed time is over, "My seed is sown: God will give it increase:" on the contrary, plants of this description require continued attention and repeated culture. It is true that the total amount of labor required for this purpose is in many cases but trifling: but the operations of which we are speaking are not on that account to be dispensed with; and what is more, they must be executed at certain precise times: the delay even of a single day may often be attended with the most mischievous consequences, particularly if it be necessary to take advantage of a favorable state of the weather, and a particular degree of humidity in the soil, which last but for a short time Whoever undertakes this branch of husbandry on a large scale, must be able to comprehend at a glance the whole space over which his operations extend, as precisely as a gardener surveys the limited extent of ground on which he works: he must give to his produce all the attention which it requires, and, as far as possible, remove from it all that may be hurtful.

It is not sufficient to calculate the mere cost of the operations which must be performed by manual labor and with the aid of horses. The time over which these labors extend is very short.—Trifling as they may be in the sum total of the labor required, they are, nevertheless, very troublesome at the precise moment when they are wanted. They occur at a time when all the available resources are required for gathering in the ordinary produce; and the cultivator may, therefore, be reduced to the alternative of sacrificing either the one or the other. Hence, in the culture of each of these vegetables, it is necessary to calculate when this particular time will arrive, and how the operations then required can be reconciled with those of other parts of the economy. An extraordinary state of the weather may retard the proper period: generally, however, the rates of growth of different plants appear to preserve the same ratio one to another; so that, when one is accelerated or retarded in its growth, the others are affected in a similar manner. But we must know how to calculate accordingly the time for sowing or planting, and always be in advance with each operation. A harvest as much before the usual time as that of 1811 causes a very troublesome interruption in the regular succession of agricultural labors.

The difficulty of this calculation increases with the number of marketable vegetables cultivated together. If a selection can be made in such a manner that the operations required by the different plants which are raised together shall follow one another conveniently, a great variety then becomes advantageous, and accords well with the general circumstances of the establishment.—The same laborers may then be constantly occupied in the same kind of work, and thus be rendered more skillful at it: and, moreover, wherever there is a continued supply of work, a sufficient number of laborers may generally be obtained for moderate wages; but there is always a difficulty in obtaining them when they can be employed but for a short time, particularly if they are of that class who may be entrusted with operations requiring particular attention and long practice.

A cultivator who does not know how to make a judicious selection, but is induced, regardless of the preceding considerations, to cultivate those vegetables only which yield the largest return when perfectly successful, will not fail to pay for his imprudence by serious losses.

But few of these vegetables can be taken to market immediately after they are gathered; they require store-houses to keep them in, as well as particular implements and modes of treatment. and these store-houses must often be built on a very large scale. Now, all these things demand

considerable outlay; and when such undertakings are limited to the production of a single species of vegetable, the capital soon becomes loaded with a very heavy interest. Commercial fluctuations, too, may reduce to nothing the profit anticipated from the production of this particular article, and then all the capital invested in it is dissipated. Establishments for the production of vegetables for the market must, therefore, be so ordered as to admit of the culture of different species, either at once or in succession.

A prudent cultivator can never be at a loss for a market to dispose of all his useful produce; but it may happen that many portions of it do not admit of being immediately sold to the consumer, but must previously pass through the hands of the merchant. Now, the merchant is not to be blamed for so far acting up to the first principle of his trade, viz., to *make the most of every thing*, as to endeavor to buy at the lowest possible price, and to take advantage of the cultivator's embarrassment, especially when the latter is in want of money. It is therefore necessary, before we undertake to raise produce of this description, particularly in countries where it is not in actual use, to make ourselves acquainted with the mercantile circumstances of the country, and, as far as possible, to make sure of a purchaser beforehand. Should this be impossible, operations must be restricted to the production of those vegetables the sale of which is, to a certain extent, fixed in the country; and such are always to be found.

The price of this produce is always fluctuating: we can never reckon upon the maximum of a series of recent prices; for, indeed, it is precisely the existence of a very high price which soon brings on a very great depression; because, all who are able to produce the article in question are induced by the high price to devote themselves to its cultivation, and, consequently, the market is completely glutted with it. It is often prudent to check the production of one plant, in order to increase that of another, when the demand for and price of the former have risen to such a hight as to induce every one to speculate in it. On the other hand, a prudent cultivator will not easily be induced to abandon altogether the production of a plant of first-rate utility, and break up all the arrangements which he has made for the purpose, even when the price has fallen very low. He will rather wait patiently in the hope that the price will soon rise again; because, under such circumstances, the greater number of cultivators become disgusted with the production of the plant in question. It is thus that the great variations in the price and cultivation of hops, madder, and woad have risen in several countries in which the production of these plants had been naturalized: it was entirely abandoned when prices fell low, and was not resumed until the favorable moment for reaping the greatest advantage from it had already passed.

The cultivator whose operations are conducted on a large scale should choose from among the vegetables of this class, and especially from such as are used in his own country, those in particular which, by a proper division of labor and the use of suitable implements, can be cultivated without much expenditure of manual labor; for where mere labor is concerned, he will rarely be able to compete with the small cultivator, who executes such operations assiduously with the help of his family. The latter, content with a small profit, offers his produce at a low price, so that it is the merchant, and not the cultivator, who is enriched by it.

We are fully disposed to admit that the production of vegetables for the market is the highest aim that an enlightened agriculturist should have in view, since this branch of husbandry is really more profitable than any other; but we are also of opinion that he should not devote himself to it without considerable caution, but take it up by degrees, and assure himself beforehand of a plentiful and continual supply of manure.

I have thought it my duty to define, by the observations just concluded, the true limits between the seductive praises which some persons have lavished on this branch of Agriculture, and the discouraging objections of others.

OIL-PLANTS.

The plants most commonly cultivated for the production of oil, belong to the genus *brassica*. This race of plants has, in the course of cultivation to which it has been submitted from time immemorial, undergone such remarkable modifications, and produced so many varieties or degeneracies, that there is considerable difficulty in distinguishing and separating its different species; viz., those which have acquired a certain permanence of character; and still more in investigating their origin, and determining by what crossings they have been produced. We shall here notice only those varieties which are cultivated in preference to others for the production of oil; though, in fact, all plants of this genus produce seeds containing considerable quantities of oil, and are sometimes used for obtaining it.

All plants of this family appear to be biennials; so that it is not till the second year of their existence that they shoot forth their flower-stalks and produce seed. One species only appears to form an exception to this rule, viz., the spring colza or field-cabbage *(brassica campestris)*. This plant is not, as some suppose, a degenerated variety of autumnal rape, or cole-seed, but really a distinct species.

Colza and Rape (Autumnal Varieties).

We shall first notice the plants of this kind which are sown in autumn. There are two essentially distinct species cultivated; they are, however, often confounded, both in name and in mode of cultivation; but it is of importance to the cultivator to be well acquainted with their differences.

One is the *brassica oleacea laciniata*, a variety of the garden cabbage. It is commonly known by the name of *colza*, or *large colza*, from the German word "*kohl-saat*," signifying cabbage-seed.

The other kind which is called "*rape*," is a variety of the *brassica napus*. It is more common in Germany than the former, because it may be sown later, and thrives on a less fertile soil; moreover, many persons cultivate it because they are unacquainted with colza, which they would otherwise find more profitable and less precarious. To enable the practical cultivator to distinguish readily between these plants, I shall here exhibit their distinguishing characters side by side.

COLZA—(*Brassica Campestris*).	RAPE—(*Brassica Napus*).
(*a*). Belongs to the cabbage tribe, and resembles the plants of this family in all its characters.	(*a*). Belongs to the radish tribe, and bears a greater resemblance to the plants of that family.
(*b*). Principal root cylindrical.	(*b*). Principal roots fusiform, closely resembling that of the radish: when the plant has room to spread, it sometimes produces a true radish.
(*c*). Leaves smooth, fleshy, bright, green, sometimes (especially the lower ones) copper-colored, and covered with a whitish down.	(*c*). Leaves hairy, thinner, less rounded at their extremities.
(*d*). Stem strong, giving out no branches from its lower part; but, above a certain hight, throwing out branches which spread more in the horizontal than in the vertical direction.	(*d*). Stem not so strong, throwing out from its lower part branches which form an acute angle with it.
(*e*). Flowers, bright yellow, come out and ripen late.	(*e*). Flowers deeper yellow, come out and ripen earlier.
(*f*). Siliquous and seeds large.	(*f*). Siliquous and seeds smaller.
(*g*). Requires early sowing, that it may take root well.	(*g*). May be sown later.
(*h*). Under these circumstances, it is strong, and stands the winter well.	(*h*). More delicate, and easily destroyed by the winter.

It is not uncommon to find these two plants confounded and mixed together, and, in countries where both are cultivated, to meet with a hybrid variety; at least I think I have seen it. This intermingling of the two species is altogether improper, especially on account of the difference in their seasons of maturity; no pains should therefore be spared to procure the seed of one species or the other unmixed.

In countries where these plants are much cultivated, they are both included under the denomination of autumnal plant-seed, or simply plant-seed, a circumstance which has given rise to frequent misunderstandings between cultivators, both in those countries and in others.

These two plants may be perfectly well cultivated on all soils which are proper for wheat and barley, but chiefly on those containing from 50 to 60 per cent. of sand, together with a small quantity of lime.

A condition absolutely necessary for the success of these plants is, that the soil be completely purified and drained; for dampness in winter is always fatal to them. When this condition is fulfilled, colza will also thrive on the light but rich soils of alluvial basins, especially when it is sown early in the season and enabled to take firm root. But rape absolutely requires a soil having some degree of consistence; on a lighter soil it is easily uprooted by frost.

A very rich soil is required for colza, more even than for rape: these plants must, therefore, be raised on a soil which is either naturally fertile, or has received more than double the ordinary quantity of manure. It is also necessary that the manure be easily soluble; and, consequently, that the stable dung be in a somewhat advanced state of fermentation, and well mixed with the soil. It is often the practice to manure the land with dung, bury the dung by one of the early plowings, and then, before sowing, to turn the sheep into the field.

It is equally necessary that the soil be well cultivated and pulverized. The plow and the harrow must be used at least four times; and in the plowings which immediately precede the sowing, the roller is also brought into use for the purpose of minutely dividing the vegetable soil. In general, therefore, the cultivation of these plants extends over two years; and the rent of the land during all that time must be placed to their account. It is true that we not unfrequently see rape (with colza the method would utterly fail) sown on the stubble of rye, after the land has been hastily manured and plowed two or three times. But this method generally produces but a very poor crop, not amounting to more than half the usual quantity; and besides this, the soil is thereby exposed to become infested with weeds. I have seen very good lands, which had been treated in this manner at short intervals, become deteriorated and exhausted to such a degree, that it was not till after several fallowings that a satisfactory crop of wheat was again obtained from them. Every cultivator, whose views are ever so little extended, should beware of adopting so ill-advised a method.

Better results have been obtained by raising two successive crops of these plants on the same land; devoting the interval between harvest and seed-time to a careful cultivation of the soil, and manuring it well, if it be not already in a state of great fertility.*

When a field of clover has been well covered, we may yet obtain a crop from it in the sowing year, provided we mow early, so as to be able to plow the land three times more. But the soil must be thoroughly cleansed from dog's-grass. The land may also be made available for raising a crop of tares, to be mown in the green state; provided it be plowed once before sowing the tares, and twice after they are gathered.

The usual time for sowing colza is from the middle of July to the middle of August; it may, however, be safely sown at an earlier part of the season, for it never produces seed the first year. The time for sowing rape is from the middle of August to the beginning of September.

The sowing should take place as soon as possible after the plowing intended as a preparation for it. As soon, therefore, as this plowing is finished, the ground should be harrowed for the purpose of leveling it, and afterward rolled. The seed is then to be put into the ground, the harrow passed lightly over it, and also the roller, if the soil be dry. If, however, a heavy rain should fall either during, or immediately after the sowing, there will be no necessity either for harrowing or rolling, since the seed will then be sufficiently covered without these operations. If the soil should be much clotted by the rain, it will be useful to pass the harrow lightly over it before the seed comes up.

It is particularly important that the seed be uniformly distributed over the land. The best plan is not to use more than five pounds of seed per acre, and to sow it in such a manner as not to

* Vide "Thaër's Vermischte Schriften," 1er Band. S. 426, A.

leave any vacant spaces; for when the plants are very close together, they retard one another's growth, become weakened during winter, and die; but when they are farther apart, they become strong, and able to resist the injurious effects of particular states of the atmosphere. Even when plants unequally sown are able to live through the winter, those which are too close together are, notwithstanding, stunted in their growth, and rarely capable of ripening their seed. For colza it is therefore of great importance to employ a skillful sower; if we hear of one living at any distance, we ought by no means to hesitate about engaging him, and paying him a ducat per day if he demand it. A bad sower may cause the crop to fail. If we cannot depend on the skill of the sower, it is better to sow eight pounds of seed per acre.

The land should be provided with good ditches and drainage furrows, for carrying off the water. In winter, during a thaw, all possible care must be taken to keep the drains clear.

If, toward the end of summer, a great number of weeds, particularly of the wild mustard tribe, should spring up among a crop of early sown colza, they should be cut while in flower: even if the leaves of the colza should be cut at the same time, the plants will not be injured. In this manner, a considerable quantity of fodder may be derived in autumn from a field of colza.

If a field sown with colza enter upon the winter in good condition, the plants being healthy, of a deep green color, neither too crowded nor too far apart, and, lastly, if the arrangements for draining and carrying off the water have been judiciously made, there is every reason to hope for a good crop; still, however, there is something to be apprehended from the critical period at the end of winter. A continued alternation of thaw and frost uproots the plants and kills them. The melting of ice and snow under the rays of the sun, and the frost which follows in the night, are dangerous to all crops which grow during winter; and the more so in proportion as the upper layer of the soil is more saturated with water, which is unable to pass off through the lower stratum, because that stratum is frozen. Under all these circumstances, it is impossible that the seedlings may be destroyed, even though they have been sown with the utmost care.

Besides the plant-louse, which attacks it immediately after seed-time, colza is also subject to the ravages of other enemies, viz., the mouse, the weevil (which lays its eggs in the flower, whence there springs a worm that feeds upon the seed-vessels), and the glow-worm *(nitidula ænea)*. It is said that these insects multiply with peculiar rapidity in districts where the cultivation of plants of this kind has long been practiced.

Such are the ordinary principles of the culture of rape and colza; for these plants do not differ in any respect excepting those already pointed out. But in the Netherlands, and the countries bordering on the Rhine, and likewise in some parts of England, the practice of transplanting has been long established, particularly with regard to colza. Wherever the value of a fertile soil is great in comparison with the price of labor, this method appears to be almost universally followed; because it admits of a great part of the land being made available even during the year in which the transplanting takes place, and, at the same time, affords an opportunity for executing the necessary plowings. Various descriptions have been given of this method, but the most accurate is that of Schwertz, in his excellent work on Flemish Agriculture.

Transplanting is performed either after plowing, or with the spade or dibbler. As I cannot speak of this method from my own knowledge, I must refer my readers to the work of Schwertz; which will, doubtless, be in the hands of every cultivator who wishes to adopt the method.

On the other hand, a method which Schwertz describes as very successful in his own hands, viz., that of drilling in rows, separated by considerable intervals, is one with which I have long been practically familiar, and which I shall probably always adopt in sowing colza for seed. I trace furrows for the marking-plow, two feet apart, and sow the colza with the radish-drill. This operation is performed on a well prepared soil; the tracing out of the rows being preceded by one more cultivation with the extirpator and leveling with the harrow. I have never tried Schwertz's method of sowing colza in this manner on a soil on which a crop of ripe grain had been gathered the same year; but I have done it after a single cutting of clover, or after tares mown in the green state. After seed-time, the roller is passed over the ground.

When the plants have put forth their fourth leaves, the horse-rake, armed with three horizontal knives, is passed between the rows; and if the plants are sufficiently advanced, they are earthed up with the horse-hoe after Michaelmas-day. If wild mustard and charlock make their appearance between the rows, they are pulled up; it is rarely that the crop is infested with any other weeds. I have never found it necessary to earth up twice before winter; such a proceeding might, however, be useful.

The earth laid up against the rows prevents the colza from being uprooted by frost; for the trenches formed by laying up the earth, completely protect the plants from moisture, provided the field have ditches, in good condition for carrying off the water. When this arrangement is observed, I do not think that there is anything to be feared from the winter.

In the spring, as soon as the plants begin to shoot forth, the earth is again laid up.

There is ample time for putting in the seed; viz., from the beginning of July to the middle of August. The land must be kept in readiness, and the seed sown during rainy weather, in order that the plants may shoot up quickly, and be safe from the attacks of plant-lice. However distant the rows may appear, the plants spread out their branches so widely, that the field will always be well covered by them.

The season of maturity of these vegetables, which is usually the middle of June, should be carefully attended to. We must not wait till all the seed-vessels are ripe. As soon as those which ripen the earliest begin to turn brown and transparent, and the seeds to acquire a blackish-brown hue, the crop should be gathered without delay; for if the gathering be delayed, the plants will shed a great portion of their seed.

There are various modes of gathering this crop.

When the seed has been sown broadcast, the scythe may be used; but it must be without rods or cradles. The crop is heaped up, lifted, and made up into bundles at once. All these operations are easily performed and without much loss of seed; but where the sickle is in use, reaping

is preferred. When the weather is dry, both these operations are best performed early in the morning; or even at night, when the moon shines and the dew is on the ground.

There are two ways of harvesting this crop. One consists in housing it in barns; the other, in threshing it on the field. If the former method be adopted, it is usual to tie up the crop in bundles not exceeding 10 lbs. in weight; and for this purpose the several portions are collected, not with the rake, but by hand. This is usually done the day after mowing, or on the following day at the latest. The sheaves are then collected in heaps, of greater or less magnitude; large heaps are, however, preferred, because the seed is then less in danger of dropping from the pods and being devoured by birds. If the sheaves are left on the ground for any considerable time, they are covered with straw. Even if rain should fall, and continue for some time, the sheaves are, nevertheless, suffered to remain without being turned; for the seed is not injured, even though the straw should become heated and give out a peculiar odor. But it would be liable to shed if the sheaves were disturbed.

The crop is usually housed after five or six days. The wagon used for carrying it must be provided with large sheets or cloths, to collect the seed which falls from the sheaves. These sheets are fastened to the ladders in such a manner as to have their edges raised.

If the seed be disposed to drop from the pods, a large sheet or cloth is also placed before the heap every time that the wagon is loaded, and one side of the wagon is made to pass over it, so that all the seed which falls may be collected. The loading is performed with great care, and in such a manner that the sheaves may project but very little beyond the ladders; and the wagon is drawn by two horses only, though the team is usually composed of four.

The crop is shot upon the threshing-floor, unless there be in the barn a space boarded and perfectly clean, on which it may be deposited.

This crop is usually threshed as soon as possible, in order that it may not interfere with operations at harvest time and likewise because the grain is more easily separated at an early period than after the straw has sweated; the straw is also preserved in better condition.

The grain is separated from the chaff by winnowing, and the larger pods by means of a coarse sieve. The finer part of the chaff remains for a time mixed with the grain, and is not separated till the latter is perfectly dry; the separation is then effected by means of a fanning-machine.

Care is taken to spread the grain so that the thickness of the layer shall not exceed four inches, and at first to stir it often with the rake.

The other method is much practiced in districts where colza has for a long time been cultivated on extensive tracts of land. In Marshall's "Description of the Agriculture of Yorkshire," vol. ii. page 103, there is a very excellent description of the ordinary mode of threshing colza. I have seen this mode of threshing established in the same manner, attended with the same practices, and likewise regarded as a general festival, in the provostship of Preez and Kiel: it is also practiced in the western part of the low countries bordering on the Baltic. But, if an individual cultivator adopt this method, the treading out of the grain by horses will certainly be found advantageous: this method is described by Kaehler, who has extracted it from the diary of a journey which he made in Holstein. This description is found in a work entitled "Hanbuch für Landwirthe." In order to make this method known to such of my readers as are not in possession of this work, I cannot do better than transcribe the author's account. It is as follows:—

"At nine in the morning, the proprietor, M. Niemyer, had the kindness to go with me to the colza-field. I was struck with astonishment at sight of the immense space of ground covered with the plant; a great part of the crop was extended on the stubble: but another, and much larger portion which had been mowed, was collected in little heaps of 6 or 7 feet in hight.

"Everything was in full activity: the colza was being carried, and at the same time, trodden out by horses on the field. Sledges drawn by two horses were used for carrying and collecting the colza. On each sledge was placed a hand-barrow, with two rods crossing in the middle, and having a large cloth, from 32 to 36 square feet in surface, stretched over them. Three similar sledges followed one another in a line. One of these files was at work near the colza, which was lying on the ground in breadths. Four women were employed in loading the sledges: they lifted the colza with a stick about three feet in length, which they held in the right hand; and while they kept it in equilibrium with the left hand, the whole was placed on the cloth without the least effort. Whenever a loaded sledge moved off, there was an empty one ready to take its place, and everything went on without interruption.

"We arrived at the heaps. Here also was a file of sledges employed in carrying the crop, the operation of loading going on much more quickly than in the former case. Two men were at hand, with levers, from 8 to 18 feet in length, and very light, ready to lift the parcels of various sizes on to the large cloth. This part of the work went on with great rapidity. One man took hold of the levers, and introduced them between the ground and the heaps; while another, stationed on the opposite side, was in readiness to seize the levers as soon as he could see them; and thus the whole heap was placed on the sledge.

"We next passed on to the floors on which the crop was threshed: there were two of these floors placed at some distance apart. The ground had previously been prepared by removing the stubble and stones which might be collected on it. These floors were quadrangular, each of them being 48 feet in length, and 36 in breadth, and covered with strong cloths. These cloths were raised at the sides to the hight of a few feet above the ground, and attached to feet fixed for the purpose. The entrance was on one side, and there the cloth could be lowered 5 or 6 feet.

"To each file of sledges were attached two men employed in unloading. This operation was also quickly executed; for, as soon as a sledge arrived, the handles of the barrow were seized by two men, one in front and the other behind, who removed the whole to the floor, turned it over, replacing the barrow and the large cloth on the sledge as soon as they had unloaded it. In this manner the operation was continued till the floor was covered with colza to the thickness of about 6 feet.

"The entrance was then cleared, and two attendants, each leading three horses, entered and

mounted on the layer of colza. They led the horses four or five times round the floor, and then descended. The colza, thus trodden out, was then immediately turned over by several men armed with forks, and then the horses were led over it again. After they had again made a few turns, the operation was finished, and the men who had turned the colza removed the straw from the floor.

"It appeared to be scarcely possible that so trifling an amount of labor should suffice to separate the colza completely from the straw; but a careful examination soon convinced me that it was so, for I found scarcely a grain left among it.

"The straw having been completely removed, the coarsest part of the residue of the stems and seed-vessels which remained in contact with the grain was collected with the rake toward one corner of the large cloth. At this angle was placed a board three or four feet long and several feet broad. It was fixed obliquely, and in such a manner that its top projected beyond the edge of the cloth. The coarser part of the chaff was drawn along with the rake, and fell beyond the floor, cleared from the seed far more effectually than could possibly have been expected.

"The loading, turning, and raking being finished on one floor, the horses were led to the other, and *vice versâ*, so that the whole of the process was constantly going on.

"As this part of the work proceeded, the colza was conveyed by the team to the repositories, where it was deposited on the floors of the barn; and although the distance was very short, the team was scarcely equal to the work.

"Thence we proceeded to the repositories, where the operation of cleansing the colza was in progress. A barn of great width and length, with two floors boarded lengthwise, and one in the middle boarded across, was completely covered with colza. Ten laborers were employed in winnowing the colza, after a number of women had passed it through a sieve to separate the coarser portion of the chaff; and while one set of men were employed in carrying the cleansed colza to the granary, after it had been arranged in separate heaps, others were engaged in unloading the wagon which brought the grain from the field, and depositing it in heaps of considerable length, but moderate hight.

"The grain is left untouched in these heaps for about twenty-four hours; during that time it becomes slightly heated, and acquires a fine black tinge.

"I was overwhelmed with surprise at seeing so large a quantity of colza in the granary. The preceding year's crop still remained there almost entire; and as a year's crop amounts to about 1,500 tons, the quantity then collected must have amounted to 3,000 tons.

"This is all that my journal contains. Every one must surely approve of this mode of gathering a crop of colza. The work goes on with great rapidity, which is a great desideratum at a time so closely bordering on harvest. But the subject must be regarded in another point of view. Everything is done in the open air, and therefore absolutely requires a continuance of fine weather. Should rain set in, it might perhaps be advisable to take advantage of occasional fine days, to get in as much as possible of the crop. The cultivator must therefore, exercise his own judgment upon this point, and take such measures as will enable him, either in fine or wet weather, to make choice of the method which he thinks most conducive to his interest and most in accordance with existing circumstances."

Schwertz (vol. ii. p. 178) proposes as a new method, invented by himself, but not yet introduced, to stack the colza as soon as it is cut, and let it ripen in that situation. But this method is neither new nor wonderful: it was described some time ago by Reichard, and is adopted in several rural establishments in Westphalia. Reichard proposed to cover the stacks with boards and load them with stones, in order to make the temperature of the colza rise still higher. This, however is useless.

The grain is not injured by this treatment, but ripens without dropping from the pods. The straw is, however, deteriorated when the stack becomes heated. The stacking is begun by placing five or six sheaves tied together in an upright position, and side by side; a bundle of straw being laid under them. The bundles are then placed all around, and carefully arranged, with the pods turned inward and the stems outward. The stacks, when completed, are covered with straw, more to keep off the birds than to protect the grain from moisture; and in this manner they are left till the time arrives for threshing, which is usually performed in the field during fine weather.

Colza and rape are not absolutely exempt from casualties. The former is, however, less exposed to them than the latter, provided it be sown early. According to my own experience, the method of drilling protects it from the dangers of winter; the only remaining danger is from insects.

When the colza and rape are cultivated in the ordinary way, their produce varies from five to twelve bushels per acre. On a rich soil, colza yields more than rape. By the method of drilling, Schwertz has obtained as much as fourteen bushels; and according to trials which I have myself made, this quantity is by no means extraordinary. Such a crop must not, however, be expected every year. The price of colza and rape is subject to great variations. It has sometimes risen higher than 6 rix-dollars per bushel, and I have never known it lower than 2¼; four rix-dollars may be considered as the average price. Even when maritime commerce is stopped, the consumption of oil is sufficiently great to keep up the price of colza, because at such times there is a scarcity of whale oil. The price never suffers any considerable diminution excepting after a very abundant whale or herring fishery. Colza always fetches more than rape, because its produce in oil is 10 per cent. greater.

The cultivator who raises these plants on a large scale is much more likely to gain by them if he keeps his own oil-mill; because by so doing he not only makes himself independent of merchants and oil-manufacturers, but also preserves the cakes, which afford most useful nourishment for the cattle. Where oil-plants are cultivated in large quantities, an oil-press will repay its cost at a very high interest.

The straw of these plants is not of great value; but when housed in good condition, it deserves higher estimation than is given to it by those who only seek to get rid of it, and burn it for the

sake of spreading its ashes on the land, thereby confining its utility to the very spot on which it is spread. Sheep are very fond of the husks and the ends of the branches; the remainder may be advantageously mixed with the dung.

That these plants exhaust the soil to a very great extent, and do not in any case restore to it the manure which they require and absorb, is a fact respecting which no doubt can exist: all impartial persons who cultivate these plants in large quantities will agree to it. whatever may be said by cultivators who are obstinately prejudiced in favor of this branch of cultivation. Even when, as is often the practice in England and Belgium, the cakes are *directly* given to the soil as manure, the nutritious matters absorbed by the crop are not fully restored: and, moreover, a German cultivator would not easily make up his mind to deprive the cattle of this kind of food. The raising of these plants in very large quantities exhausts the land to such an extent as to render necessary the utter abandonment of this cultivation. when it has been engaged in by those who neither have the means of procuring a supply of manure from without, nor possess a sufficient quantity on their own establishments. Those who maintain the contrary rest their assertion on the fine crops of autumn grain which are usually obtained after the cultivation of these plants. But it must be remembered that, as a preparation for this cultivation, it is usual to give the land double the ordinary quantity of manure, to bestow the greatest pains on the preparatory fallowing, and after harvest to plow up the land again with the greatest care. These plants may doubtless be regarded as an intermediate crop, which serves to keep the soil light, and fertilize it by the shade which their leaves afford. It is not, therefore, surprising that the succeeding crop should always be very abundant, since the soil retains a sufficient quantity of nutritive matter; and this matter has been brought within the reach of the crop which immediately follows. But after this crop fresh manure is a most indispensable, for the success of those which follow; unless, indeed, the soil be naturally possessed of uncommon fertility. When, therefore, colza and rape are to be raised in large quantities it is necessary to bear in mind the considerations already noticed respecting the cultivation of vegetables for the market in general.

But colza may also be made very useful as a fodder plant, and in this capacity contribute as much to the welfare of the establishment in general, as to the fertility of the soil in particular. It is true that a rich soil is required for this purpose; otherwise, the colza does not grow to a sufficient hight. When colza is to be raised as a fodder-plant, it may be sown in and after the month of May; and, according to the early time of the sowing, and the more or less favorable state of the weather, we may obtain two, three, or even four plentiful green crops from it, even in the seed-year itself. It will often shoot forth early in the spring, affording the first supply of green food for the cattle. The plant may, if desired, even be allowed to run to seed; it will still yield a complete crop. If, in consequence of the soil not being sufficiently fertile, the colza should not shoot forth in the first year with sufficient vigor to furnish plentiful green crops, it will at all events afford excellent pasturage for the cattle: it is eaten with avidity by animals of all kinds, and soon shoots forth again after having been fed off. In England, colza is more frequently sown as a pasture plant, than for seed; and this mode of employing the land is considered as equivalent to a plentiful manuring. Fields are there met with which are never manured, but treated in this manner every four or five years.

Clover thrives perfectly well among colza, whether the latter be allowed to ripen, or whether it be mowed or fed off. Moreover, if colza be always used as green food, it is a good plan to devote a certain number of fields entirely to the raising of fodder for a few years; a mode of proceeding which is farther recommended by the low price of the seed of this plant.

Rape is not well adapted for fodder; and spring colza, which grows up and flowers quickly is altogether unfit for that purpose. Some persons by mistake have used it in this manner; but they have obtained a very poor crop, and only one supply of green food.

Many plants bearing some affinity to colza have been cultivated in its place: the Swedish turnip or ruta baga, has been lately brought into notice as superior to it, both in quality and quantity of seed. This opinion has been promulgated, particularly in France and Germany, by Schwertz. The seed of colza was doubtless originally derived from the plant with the fleshy root, to which this name is applied: but by growing in fields where it has been crowded, and its root has not been able to attain its natural size, the nature of the plant has at length been so far modified that at present the same seed no longer gives rise to a root of considerable thickness, even when the plant is isolated. I have for some time remarked that the Swedish turnip yields an enormous quantity of seed, and that the seed is very rich in oil. The great advantages which Schwertz and Clémens have derived from it, and the superiority over colza which they assign to it, have strengthened my own conviction, and determined me to lose no time in giving the preference to the Swedish turnip in my own cultivation.

SPRING COLZA, OR SPRING RAPE.

These two names are applied indifferently to the same plant; and this plant is totally distinct from both colza and rape. It is not, like various kinds of spring and autumn wheat, a mere variety obtained by cultivation: it is the *Brassica campestris* of botanists, the same that grows wild in many places, and in that state is commonly known by the name of wild cabbage. It is the only plant of this family which possesses the property of growing up and flowering rapidly, like mustard and wild radish. It is, therefore, a spring plant, which may be sown from the time when all danger of frost is over, to the end of June, without any risk of its not attaining maturity.

This plant thrives in a soil which is fertile, rich, and not very dry; it requires careful plowings to clear the land from weeds. In the three-field system, it is usually sown on the fallow; and, after the harvest, succeeded by a crop of some autumnal grain. This plant does not absorb the nutritive principles of the soil so much as colza: it, however, consumes a large quantity of them in proportion to the time for which it occupies the ground, and commonly yields much less abundantly than the oil-plants which are sown in autumn.

The soil being prepared, the seed must be sown when the weather is fine, but rather damp. in

order that it may germinate and spring up quickly, and thus more easily escape the injurious effects of weeds and the attacks of plant-lice. The success of the plant depends both on the weather, and on the absence of scarabs and their larvæ; and likewise of certain black caterpillars, which often attack it at the time of flowering. Spring colza ripens about Michaelmas; that which is sown early ripens sooner. It requires for the most part the same labor as autumnal colza, excepting that it is rarely threshed in the open field.

A prudent cultivator will lose no time in plowing up the crop, as soon as he perceives that it is likely to fail: otherwise the weeds will choke it, and infest the soil.

We cannot in general reckon on a produce of more than five bushels. It is only on the soil of drained swamps that a greater product is obtained; and in such situations the crop sometimes equals that of autumn colza: for these soils it is therefore a very advantageous crop, on account of the rapidity of its growth.

The seed is also less valuable, because it yields a smaller quantity of oil. It is only when perfectly ripe that it yields as much as 18 or 20 lbs. of oil per bushel. Many persons, however, raise this plant in preference to the autumnal oil-plants, because it occupies the ground for one summer only.

It is said to be not uncommon, in the Bishopric of Paderborn, to meet with spring and autumn colza sown and mixed together: in such cases, the former is gathered in the year in which it has been sown, and the latter in the following year: this is certainly a curious method.

MUSTARD.

This plant has lately been recommended as an advantageous substitute for spring colza, to be used in the production of oil.

There are two distinct species of mustard, differing from one another not only by their color, but also by other external characters.

White mustard produces siliquas rough to the touch, and terminated by a long point or horn. The color of its seed is yellow, inclining to brown. That which is called English mustard is nothing more than a variety produced by cultivation.

Black mustard has a smooth siliqua, which adheres firmly to the tongue. In Germany this species is preferred for making mustard for the table: its husks are more easily opened than those of white mustard.

Both species yield oil which is well adapted for burning; and also, when well purified, for the use of the table. A quintal of mustard-seed yields from 36 to 38 lbs. of oil.

The biting acridity of the seed exists not in the oil, but in the integument; and the English mustard, which is celebrated for its strength, is said to be made from cakes from which the oil has been expressed.

Mustard is said to thrive better than spring colza on poor soils, and to be less sensible to cold. It may, therefore, be more advantageously sown at the end of winter. This proceeding is even necessary, for mustard is particularly liable to be destroyed by plant-lice. It suffers in a less degree from scarabs and worms. It continues for a long time in flower, and affords excellent nourishment for bees; its siliquas are formed successively For cutting mustard, especially the black species, it is necessary to choose the exact time when the first siliquas are ripe.

The produce of mustard is, on the average, greater than that of spring colza. The most advantageous mode of disposing of it is, perhaps, to sell it to those who prepare mustard for the table, provided that circumstances will admit of this course. It is, however, more profitable than spring colza for the preparation of oil, because it yields a greater quantity. It therefore deserves the preference in every respect, excepting, perhaps, that it requires to be sown earlier, and therefore imposes the necessity of greater expedition in giving the necessary preparation to the soil.

The cakes which form the residue in the preparation of the oil are said to afford a mild and stimulating purgative for cattle, and in this capacity to be very useful: they are ground and spread upon the fodder given to the cattle.

OILY RADISH (RAPHANUS CHINENSIS OLEIFERUS.)

This is a variety of the common radish; it has been strongly recommended on account of the simplicity of its culture, the abundance of its produce in seed, and the large quantity of oil which it yields: it is, however, nowhere cultivated for any great length of time.

It shoots up vigorously in hight, and spreads out its long branches with considerable force: it therefore stands in need of support. It cannot easily be kept upright, excepting on narrow beds surrounded with sticks placed horizontally at a certain distance from the ground. Its seed-vessels are very liable to be attacked by the larvæ of the weevil. They ripen very irregularly, because the plant flowers continuously; and sometimes the greater number of them do not ripen before winter. If this plant could be sown in autumn, and would withstand the winter, as it appears to do according to experiments made by some persons, it might probably be cultivated at less risk: but it does not seem well adapted for cultivation on a large scale in the open field.

Its produce is, to all appearance, extraordinarily large; indeed, when particular plants are separately considered, it appears to exceed that of any other oil-plant. It will multiply ten thousand fold, and is, therefore, an excellent plant for those whose main object is a very great multiplication of seed. But the plant when isolated spreads to such an extent that it must be considered doubtful whether, in proportion to the space of ground which it covers, its produce in grain is equivalent to that of other oil-plants. The seed is said to yield 50 per cent. of its weight of oil; and the oil possesses an agreeable flavor.

CULTIVATED GOLD OF PLEASURE (MYAGRUM SATIVUM).

This plant also grows wild, and is sometimes very troublesome among flax; it grows to the hight of one or two feet. The stem is angular, hairy, and branching; the leaves are lanceolate,

and embrace the stem at their bases; the flowers are yellow, and grow in large clusters at the top of the stem. The siliquas are obovate, flattened, and terminated by the persistent filiform style.

The plant delights in sandy soils, provided they are rich; and it is on such soils that it is cultivated; but it exhausts them to a great degree.

It is sown in April, and gathered about the end of July or the beginning of August. It is less subject than other oil-plants to the ravages of insects, and seldom fails entirely. Its produce scarcely exceeds 5 bushels per acre. A bushel ought to yield from 20 to 24 lbs. of an oil, which has a slightly bitter taste, and thickens with cold.

COMMON POPPY (PAPAVER SOMNIFERUM).

Several varieties of this plant are cultivated; they are distinguished from one another by the color of their flowers and seeds, and the structure of their capsules.

The color of the flower is unimportant. The seed is either white or black. Some persons think that the black-seeded variety is the more productive; others give the preference to the white in this respect. The white seed is the more agreeable to the taste, as is likewise the oil expressed from it. That variety of poppy is preferred whose heads or capsules when ripe assume a slightly bluish tinge.

The structure of the capsules is of more consequence; for there is a variety in which the envelope of the capsules dehisces spontaneously when ripe, so that the seed is easily shed; and another in which the seed remains enclosed within the capsules, which must be opened in order to extract it. The former is well adapted for cultivation on small pieces of ground, where the heads may be cut off and put into bags as they ripen; but it is quite unfit for cultivation on a large extent of surface, where it is desirable to gather the whole crop at once.

The poppy requires a rich soil, containing a large quantity of humus, and well prepared for its cultivation. When it is to be raised in the fields, the soil selected for it must be of the best quality, the most completely manured, the cleanest that can be found, and, if possible, somewhat sheltered from winds. It must be one which has been prepared and manured the year before, because poppies thrive better the sooner they are sown.

It is a favorite plan to sow them in March, even on ground covered with snow, provided the covering be of uniform thickness. This method is said to be wonderfully successful.

Poppies are sown very thinly. To ensure the proper spreading of the seed, the operation must be entrusted to a man well practiced in thin sowing, as gardeners are. A pound of seed is too much for an acre. If, however, the plants be subsequently thinned, no injury will result from their having been sown too thickly at first.*

The operation of thinning the poppies and pulling up weeds which grow among them, is absolutely necessary to their complete success. The spaces between the plants should not be less than six inches; and if the soil be very fertile and tolerably well sheltered from winds, the produce will undoubtedly be greater when the plants are even twelve inches apart. When poppies are too crowded, they produce but small capsules, containing very little seed, and that, too, of inferior quality. The operation of thinning is performed much more easily, and with far greater benefit to the plants, by the use of a mattock or hand-hoe, than by pulling up the weeds and superfluous plants by hand; at least, if the laborers are accustomed to this kind of work; for, by the former method, the earth is at the same time lightened, and, to a certain extent, heaped up round the plants.

The cultivation with the hoe, or the pulling up of weeds, must be repeated, if it has not been properly performed the first time, or if the weeds again make their appearance.

Poppies are often sown among carrots; and as the carrots have still two months to grow after the poppies have been torn up, this method doubtless tends to make the land yield as much as possible. but it interferes with the full effect of the hoe cultivation just spoken of, and likewise with the regular thinning of the poppies and carrots—a condition which must nevertheless be fulfilled, if we wish to obtain the best crop that the land can yield.

It is necessary to take advantage of the precise time when the poppies are ripe. Now, this is the very season when the harvest-labors are in full operation, a circumstance which renders the culture of the poppy very difficult in large rural establishments. If, however, the poppies ripen all at once, which may be effected by sowing early and taking care to thin them well, the labor of gathering is not very great. The crop must not be suffered to stand too long, as it will then be attacked by rooks, sparrows and mice. The mice gnaw the plants close to the ground till the stem falls, and the capsules are thus brought within their reach Neither must the fruit be gathered before it is ripe, for the seed will then have a bitter and disgusting flavor, and the oil will not be fully developed. The stems are cut close to the ground; or, if the soil be light, the plants are pulled up. They are then tied up in bundles with straw placed round them close to the capsules, and housed as quickly as possible. The lower parts of the stem are cut away as far as possible, and the bundles deposited in a well-covered and well-aired situation till they are thoroughly dried.

The poppy-heads are then opened separately by hand, and emptied by turning them over and shaking them. If there are no feeble old men or children on the establishment, this operation is very troublesome, for it must be performed precisely at the time when there is the greatest quantity and variety of work to be done. Poppies raised in large quantities are usually threshed† to sepa-

* The poppy cannot be transplanted: it would be useless to endeavor to fill up the vacant spaces by this method; even in weeding it while young, great care must be taken to avoid injuring its roots.

† The operation of bruising and pulverizing the capsules a little, is apt to leave a small quantity of their substance, which is bitter and narcotic, among the seed. It is, therefore, essential to the goodness of the oil, that the seed be taken out of the capsules by hand, and then passed through a sieve fine enough to cleanse it perfectly. [*French Trans.*

rate the seed from the capsules; or else the capsules are cut open with a machine, and the seed is separated by winnowing, or by the use of the sieve, or the fanning machine.

When the seed has been cleansed, it is conveyed to a granary which has a very close grating; or, if there be no such accommodation at hand, it is spread on a large cloth. At first, it is frequently stirred, and afterward, when quite dry, put into casks, in which it is kept.

The poppy may become one of the most profitable crops if we have the means of disposing of the seed, or if we know how to extract the oil. By proper cultivation it may be made to produce from nine to ten bushels of seed per acre, and one bushel yields 24 lbs. of good oil. This oil, especially the first portion, which is cold-pressed and mixed in the mill with slices of apple, is doubtless the purest kind of oil for the table, and the most agreeable that is known. It is inferior to none, excepting, perhaps, the finest Nice or Lucca oil. It is preferable to the second-rate oils of those places, and the peculiar taste of olive-oil may be imparted to it by the addition of a small quantity of that oil of superfine quality. But the seed may often be sold in its natural state, and we can readily obtain a Frederick-d'or per bushel for it. But notwithstanding this large return, the cultivation of the poppy is in some establishments attended with so many difficulties, that the great cultivator ought to think more than once before he undertakes it.

There are other plants whose seed may be used for the production of oil, but respecting which this mode of application is but a secondary consideration. Of this number are flax, hemp, and tobacco, of which we shall presently treat. There are others again which are cultivated in gardens only, such as the sun-flower *(helianthus annuus)*: these I content myself with mentioning.—Their seed certainly produces a good table-oil, and the return from it may be considerable; but the gathering and preservation of them in granaries are attended with so many difficulties, that they cannot be recommended to the cultivator, but must be left to the province of the gardener, who may sometimes raise them to advantage among his other produce; for these plants always thrive better when isolated, than when crowded together in the field.

The cultivation of gourds has also been recommended for the sake of their seed, which indeed produces an oil of very agreeable flavor, though small in quantity; but the raising of them must, for the most part, be left to the gardener.

I shall also merely allude to the wild mustards, charlocks, and radishes, which no cultivator would purposely raise, but which are too often found in abundance on his land; and may, if carefully separated, be used for the production of oil.

THREAD PLANTS—FLAX.

The culture of flax and the manipulation of its thread, are treated in full detail, not only in agricultural manuals and treatises, but also in various essays written expressly on the subject; and the directions given in these works are, according to the various degrees of merit of their authors, sufficiently exact to render it superfluous for me to enter at length into the consideration of this matter. Moreover, the manipulation of flax and the preparation of the thread are sufficiently well known to all practical cultivators, and all details relating to the latter of these objects are more easily and effectually learned by inspection, than by the perusal of written directions. After the seed has been sown, the remainder of the work belongs to the women's province, and may be most advantageously entrusted to them: they usually take very great interest in the success of the crop. I shall, therefore, confine my observations to one or two principal points, which, in my opinion, have either not been treated so clearly and fully as they deserve; or, on the other hand, appear to be yet involved in doubt.

Opinions are much divided respecting the advantages which may accrue either to the great or the small cultivator, from extending the culture of flax. If one person sees in it, and with reason, an interesting branch of industry, another, on the contrary, regards it, not without reason, as a leading cause of the decline of agricultural prosperity.

It is certain that flax absorbs in a peculiar manner the old nutritive particles remaining in the soil; that it requires long and tedious cultivation; and that, too, at a time when there is a superabundance of work to be executed; and, consequently, that it may cause the neglect of some operation of particular importance to the welfare of the establishment in general. It follows, therefore, that in places where the old system of cultivation is pursued, where economy is necessary, with regard either to the quantity of manure and the nutritive matter contained in the soil, or to the amount of manual labor and the employment of time in summer, on account of the thinness of population, it is impossible that advantage can result from any great extension of the culture of flax. But on a soil which has been fertilized by repeated ameliorations, and in establishments in which abundance of manure is produced, and there are plenty of hands, especially women, the cultivation of flax may be undertaken without inconvenience.

In countries where spinning and weaving form the principal resource of the people during winter, it is particularly advantageous to give this kind of produce the preference before other marketable plants. In such countries one often has the opportunity of selling the crop as it stands, and thus clearing a considerable net profit, without the trouble of gathering and subsequent treatment. It may be a good speculation to establish spinning-rooms and looms on an estate, for the sake of conveniently employing during winter a number of laborers, who may afterward be occupied for the summer season in agricultural operations. In this manner we may increase the number of well disposed people about us, and also the population in general. Under such circumstances, it is, doubtless, advantageous to extend the culture of flax and the preparation of the thread: and, what is more, this extension may be made without inconvenience. But if these two circumstances do not exist, the culture of many other marketable plants seems to me to be preferable to that of flax: the latter should, I think, be then restricted within such limits as are prescribed by the wants of the establishment itself.

Flax prefers a light soil mixed with sand, to a strong clayey soil. It is, however, necessary that the deficiency of power to retain moisture which results from the composition of the soil, be made up by its situation. It is, moreover, essential that the soil be rich and fertile, either by nature, or

from having previously received an abundant supply of manure. The want of this fertility cannot well be supplied by manuring the land at the time of sowing. The soil must not, however, be immoderately rich; for the flax would then be very likely to be laid. A light, marly soil agrees with it better than any other.

In countries where the three-field system is practiced, it is almost always the custom either to sow flax on the fallow-field, or to substitute it for fallowing. This place appears to me the most inconvenient that could possibly be assigned to the plant. It is difficult, especially in raising fast-growing flax, to give the land that complete cultivation which ought to precede the sowing; especially when the soil has become greatly infested with weeds from the raising of several successive crops. Flax is regarded as a bad preparation for autumn grain; and every practical cultivator reckons on a sensible diminution in the produce of grain which is immediately to follow a crop of flax. In the three-field system, I should much prefer to put the flax on the spring-corn field, which may much more easily be prepared in the manner required, especially if the fallow preceding the autumn grain has been carefully attended to. If this fallow-field has been plentifully manured, it ought to possess considerable fertility. In that case, especially after the autumn grain has been removed, it would be necessary to clear off the stubble superficially, or simply give a half-plowing, and afterward in autumn to plow deeply. If the soil appeared to require fresh manure, I should have a quantity of perfectly fresh stable-dung carted on to it during winter, and spread over the surface, after the harrow had been passed over it. The dung would remain in this state till dry weather in spring would allow me to have the straw raked, or, as would be more convenient on large surfaces, to have it collected in little heaps, by means of a large harvest-rake drawn by a horse; the remainder would then be taken away, to be used for other purposes. The land would thus obtain the nourishment required for the crop of flax, without being too much raised by the straw. Instead of this, it may, doubtless, be advantageous to turn the sheep on to the field. The plants will then vegetate powerfully: but, above all, the soil will be rendered very porous, and, after one plowing, will be well prepared for the reception of the seed. Peas will thrive well on land which has borne flax in the preceding year; and the autumn grain which follows the peas will succeed better than it would if sown immediately after the flax. This, however, supposes that it has not been thought preferable to sow clover among the flax; a plan by which clover succeeds better than by any other, unless, perhaps, among buckwheat.

But flax is also perfectly successful when sown after clover on a single plowing, especially if the clover be biennial. The stubble of the clover is plowed up either in spring or autumn, with some care, and not too superficially; and then the harrow and roller are passed over the ground.

Before sowing flax, the harrow with projecting teeth is forcibly passed over the surface; or else (and this is the better method) the extirpator is used. The flax is covered with the harrow, and the roller passed over the surface. The mode of manuring just described may be here adopted if the flax be thought to require it; but a slight manuring with lime, soap-boilers' ashes, or the dung of fowls, especially pigeons, scattered at random, will be found more beneficial.

On the other hand, according to the observations of the Belgians, flax does not succeed after legumes, especially peas. It is perfectly successful after weeded crops which have been well manured; it is also cultivated with advantage after hemp; but hemp must not be sown after flax.

Flax never thrives better than on a rich and fertile clearing, or land which has for a long time been laid down to grass. I think it would be difficult to find a more profitable mode of employing such land for the first year of its return to cultivation. It must be scarified more or less deeply, according to the thickness of the layer of turf: the latter must be carefully turned over; and for this purpose, the fork or the spade must be used in places where the plow is insufficient. This operation should be performed in autumn, or in early spring; and the ground harrowed and rolled immediately afterward, to prevent the grass from coming up between the furrows. At seed-time the ground is strongly harrowed, then the seed is put in and buried with the harrow, after which the roller is passed over the surface. I have never seen flax growing more vigorously and firmly, or with longer stem, than on a clearing of this description: a farther advantage is that the ground does not require weeding. At most, it is only the roots of a few weeds which are hardy and difficult to destroy, that shoot up again; and these are easily pulled up. The turf under flax becomes so light and porous that a single plowing is sufficient for the winter grain. On a clearing, the soil of which was rich and fertile, I have in this manner obtained a very good crop of wheat after one of flax. I was induced to give the preference to this first grain, from the circumstance of a crop of rye having been laid the year before, when sown after flax which had been grown on a clearing. I know of no crop under which close turf becomes more friable.

When I have no clearings, I cultivate flax exclusively in hollows situated in the fields, devoted to the autumn grain, where I should otherwise fear that the water would remain during the whole winter, or where this inconvenience has actually been experienced. If the extent of these hollows is but small, I go to the expense of having them cultivated with the spade; and a short time before sowing, I manure them with a mixture of compost and lime, which together with the seed, I bury with the harrow. In this manner I obtain as much flax as I want, and even more without devoting useful land to it; and, at the same time, I keep in cultivation portions of land which would otherwise become acid, and produce rushes and other marsh plants.

Flax must not be grown again till after a considerable interval, on land which has once borne it. It is thought that a space of at least nine years ought to intervene between two crops of this plant, even in countries where the soil appears best adapted for its cultivation, and where that cultivation is most successfully carried on—as for example, in Belgium.

It has been laid down as an essential condition for ensuring the success of flax, that the seed must be renewed every three, or, at all events, every four years, by procuring Riga flax-seed, which grows in Livonia, Courland, and Lithuania. Experience has shown beyond a doubt that our hemp-seed becomes gradually bastardized, and produces, year by year, plants which grow to a less hight, and especially branch out too soon. We are, therefore, obliged from time to time to purchase this costly seed at the price of from 18 to 22 rix-dollars per tun of two bushels; while we

ourselves sell it for only 3 or 4 rix-dollars. As to our flax-seed, it is neither the climate nor the soil that occasions its deterioration, but rather the scanty attention bestowed upon the crop. We do not allow the seed to ripen, but separate it too soon from the stalks; and, consequently, we cannot prevent it from being somewhat burnt, and changing its color from a yellowish tinge to brown. In the countries bordering on the Baltic, where the sale of this seed constitutes an important branch of commerce, it is treated with great care. The flax intended for seed is sown much more thinly than that which is designed for other purposes; and the soil chosen for it is mostly a clearing, from the surface of which the turf has been peeled off; the flax is allowed to ripen completely, the fineness of the thread being sacrificed to the quality of the seed: the seed-bearing branches are then cut to the length of a span, and wound in a spiral direction round a rod. The rod is then straightened, and the flax-seed left till it becomes perfectly ripe and dry; after which it is threshed. By this process the seed is made to preserve its yellow color, its lustre, and the agreeable odor which is peculiar to it: in this state it produces more vigorous plants. It is certain that by following the same process we might obtain flax-seed quite as good as that which we get from abroad, and thus save the high price which we are obliged to give for it. Experience shows the utility of keeping flax-seed for two years; according to some persons, it continually improves by keeping.

There are two sorts of flax: one bearing seed-vessels, which burst with a report, when, after ripening, they are powerfully dried by the sun's rays: its thread is fine, short and pliant. And another, which requires threshing to separate the seed. In Germany, the latter variety alone is cultivated, the former not being considered profitable. The distinction of early, medium, and late flax, depends entirely on the time of sowing; for the seed is otherwise the same. The early and medium varieties appear in general to be the safest. In many parts, however, it is only the late flax that is sown, merely because it is not ready for gathering till after harvest; and it is desirable not to be hindered at harvest-time.

I say nothing about the remaining processes in the preparation of flax, because they are sufficiently well-known, and I should merely have to repeat that which has been said a hundred times over. I must, however, notice the contradictory opinions which have been advanced respecting the comparative advantages of *dew-rotting*, and *steeping* or *watering*. The former method is the safer of the two; but it takes up a great deal of time, especially in dry weather. In the dry summer of 1810, this method was impracticable: it then became absolutely necessary either to steep the flax, or, at all events, to sprinkle it frequently with water. The process of steeping is very expeditious, but it requires great care and attention to prevent the thread from being injured. It is not in all situations that a sufficiency of water can be obtained for this operation; it fills the air with putrid effluvia, and the water with decomposing vegetable matter, which destroys the fish. Then again, it must always be performed by women, who are usually unwilling to depart from established practices. It is, therefore, better to adhere to the mode of management already established in the country.

In separating the seed, the cultivator takes care to divide it into seed of the first quality, which he keeps for sowing; the seed of medium quality, to be used for the extraction of oil; and inferior seed, which may be most advantageously consumed as food for the cattle.

Perennial flax *(Linum perenne)* which is a totally distinct species, has been strongly recommended by some persons, and seems in fact to be decidedly superior in one respect, viz., that it lasts for several years (I have myself kept it growing for six years in full vigor), and produces much longer and firmer stems; but its thread is coarse, brown, and not easily separated: hence, this species of flax has never continued long in favor with any one.

Hemp (Cannabis Sativa).

Hemp is one of those plants in which the sexes are separated. A remarkable variety of this plant is that of Alsace or Strasburg, the stem of which grows to the hight of eight feet.* This great length of stem is probably the result of that careful cultivation doubtless bestowed on those plants which are raised for the sake of their seed, and of the abundant room which they have for growing. When the plant attains this hight, it is much exposed to injury from high winds. It is not yet decided whether this variety would thrive in the climate of the north-east of Germany.

For hemp, even more than for flax, the soil must be rich in humus, moist by its situation, and, at the same time, light and movable. Drained marshes not containing peat, and muddy ponds from which the water has been allowed to run off, are very well adapted for the culture of this plant, which yields, when grown upon them, a very plentiful crop. It is only on the rich lands of low countries that hemp will thrive on the whole extent of the fields. On high grounds its produce is not great, unless a large quantity of manure be bestowed upon it; or, as already mentioned, it be confined to certain low patches of ground more fertile than the generality of the land: hence the cultivation of hemp is absolutely unknown in some countries. On a well-adapted soil, hemp may be raised for many years successively on the same spot.

If the soil be not naturally light, it will often be necessary to prepare it for this crop by four successive deep plowings.

On damp soils, the dung of sheep and horses is most beneficial to hemp, on account of the heat which it affords: but when this plant is grown on a dry soil, it requires a considerable quantity of well fermented cow dung.

Hemp is sown from the middle of April to the end of May† on land recently plowed. The

*I have myself measured stems of this plant growing on my own land both in Bologna, and at Romagna, in Italy, which stood above-ground as high as 15 ft. 8 in. Rhine-measure. A friend of mine has measured some that were 18 ft. 6 in. Rhine-measure in length; and, nevertheless, the thread of these plants was remarkably beautiful.

† As soon as all danger of frost is thought to be over. I have seldom or never seen hemp injured by white frosts happening after it has come up. I should recommend that it be always sown as soon as all fear of frosts, properly so called, is past.

quantity of seed is 1 or 1½ bushel per acre, accordingly as coarse or fine hemp is to be raised. Damp weather is preferred for seed-time, and the seed is buried with the harrow. The last year's hemp-seed is considered better than that which is older, and the seed is never changed.

Hemp springs up quickly, and grows very rapidly; hence, it very soon covers the whole of the ground, and chokes the weeds, so that it rarely becomes necessary to pull them up or hoe the crop. This is one great advantage of the cultivation of hemp as compared with that of flax. The greater broom-rape *(orobanche major)* and the branched broom-rape *(orobanche ramosa)* are the only weeds which infest hemp: they may sometimes entirely destroy it. They are not found anywhere else.

The male hemp is *pulled up** as soon as it has discharged its pollen, and begins to turn yellow at the top. This change usually takes place at the end of July, or the beginning of August,† and, therefore, during the most pressing occupations of harvest. This circumstance greatly increases the difficulty of cultivating hemp, for the operation takes up a great deal of time. Hemp pulled up at this time produces the finest thread, and, consequently, it is a pity not to gather it at that time: besides, the female plants which are left standing have then more room to grow and gain strength, and, therefore yield a larger quantity of seed.

The remaining part of the gathering and preparation of hemp, is for the most similar to the corresponding part of the treatment of flax. There are, however, different methods of conducting these processes, descriptions of which may be found in various manuals of Agriculture and essays especially devoted to the subject; particularly in Kähler's admirable "Handbuch für Landwirthe."

The raising of hemp in large quantities cannot be recommended to a cultivator whose land is of very great extent, unless he has particular pieces of ground peculiarly adapted for raising this plant; and either a sufficient number of hands for gathering and preparing the crop, or the means of selling it on the ground. Hemp is everywhere an object of primary necessity for the manufacture of cordage;‡ it yields abundance of seed; and as it is very rich in oil, the disposal of it may be regarded as certain.

In rural establishments which have only now and then portions of land fit for the culture of hemp, such, for example, as ponds which have been drained, it is proper to provide in the course of one year a supply of this plant which shall suffice for several years after. I have often obtained as much as forty or fifty rix-dollars net profit per acre, although the expenses of cultivation were higher than they ought to have been.

OTHER PLANTS, THE CULTURE OF WHICH HAS BEEN PROPOSED FOR THE SAKE OF THEIR THREAD OR COTTON.

Syrian Swallow Wort, or Virginian Silk (Asclepias Syriaca).

In the years 1790-1800, this plant was loudly vaunted as capable of supplying the place of cotton, and its produce was brought into use at several manufactories, especially at Leibnitz. Since that time however, we have heard nothing of it, although circumstances have been very favorable to the production of any plant that could supply the place of cotton: we may, therefore, be allowed to suppose that it has not fulfilled the expectations which were entertained of it. Nevertheless its cultivation is extremely easy, and it thrives well in the most arid soils, provided they are enriched with a little manure.

Common Nettle (Urtica Dioïca).

Of late years the cultivation of this plant, both as food for cattle, and for its thread, has again been strongly recommended. It may be multiplied either by seed or by the transplantation of roots and stocks; and it is said to possess the peculiar advantage of succeeding on the worst soils —on sand-hills, among stones, and in other places where the ground could not be used for any other purpose. This assertion seemed to me rather astounding, because I had never seen the nettle grow to any considerable hight, excepting in situations in which there was plenty of humus; but my doubts were removed upon finding it stated, in the midst of a magnificent eulogium of the nettle, that it is necessary to put a few inches of good mould on the places where this plant is to be raised.

The cultivation of the nettle, either as a thread or fodder plant, may then be safely recommended to those who have no better means of employing their good vegetable soil, and the labor which they have at their command.

There have also been recommended as thread-plants various species of mallow, the Spanish broom *(spartium junceum)*, the common broom *(spartium scoparium)*, the rosebay willow-herb *(epilobium angustifolium)*, the stem of the hop, &c. On this subject I refer my readers to the work entitled "Herzers vollständige Geschichte der Benutzung vieler bisher noch unbenutzter deutscher Woll und Seeden-gewachse." Regensburg, 1794. Meanwhile we shall content ourselves with the culture of hemp and flax.

Fuller's Teasel (Depsacus Fullorum).

This plant must here be introduced on account of its great utility to the woolen manufacturers, who are so anxious to obtain it, that in many localities its cultivation may be very profitable.

The teasel grows wild in Germany; but the wild teasel cannot be used for raising the nap of cloth, because the prickles with which its head is armed have not the crooked points which they acquire by cultivation.

* It is much better, or rather absolutely necessary to reap it, in order to obtain a fine thread; for that afforded by the root is coarse and bad. [French Trans.

† In Italy, about a month after the wheat harvest. [French Trans.

‡ In countries where much rain falls in the summer season. [French Trans.

It is sown in spring. In the first year the plants do not grow to any hight. They are usually transplanted in July to the distance of a foot or two. In the following year they put forth stems from four to six feet in hight. The flowers appear at the extremities of the stem and branches, forming ovoidal heads, armed with long elastic prickles, between which the purple flowers show themselves. When all the flowers are blown, the heads are cut off, leaving about a foot of the stem. They are then dried in a well-aired barn, and tied up in bundles of about a hundred each.

The remarks already made on the culture of marketable plants in general, are equally applicable to the teasel.

COLORING-PLANTS.

Dyers' Madder (Rubia Tincterum).

The plant is a native of the south of Europe; but it is capable of withstanding a more northern clime.

Its roots, which are used in dying, are about as thick as a goose-quill, and often two or three feet long; they are composed of portions united by a kind of articulation, round which numerous filaments are given off. They contain a fleshy substance, which is of a deep red color without, and pale red within. Toward their upper parts they throw out lateral roots, which extend horizontally under ground, and produce new shoots in spring. The haulm dies on the approach of winter. The stems are several feet high; they bear ovate, or rather lanceolate leaves arranged in a whorl. The flowers are yellow, and supported by peduncles united at their bases in the form of a bouquet.

This plant may be reproduced by seed; but the propagation may be more rapidly effected by planting shoots which are thrown up from the root in spring. It must be observed, however, that plants, which for some generations have been propagated in this manner, lose their inclination to produce seed. Some cultivators think it useful to renew, from time to time, the production of madder from seed.

Madder requires a light, humid soil, ameliorated by repeated manurings, and recently dunged.

The soil is turned up either by the use of the spade alone, or partly with the spade and partly with the plow; or if the plow alone be used, it is made to go as deeply as possible.

The plants are sown in rows two feet apart. After every third or fourth row a double space is left. When the plants are grown up, the mould is removed with a shovel from this last-mentioned space and spread out among the plants, so that the field then presents the appearance of raised beds, separated by deep furrows.

The planting usually takes place in May; and, as the plants do not grow much the first year, many cultivators avail themselves of this interval for sowing other vegetables on the land.

On the arrival of winter, the beds are covered with dung; which is again removed with the rake at the beginning of spring, and superficially buried in the furrow.

The plants then put forth vigorously; the hollow spaces or furrows are carefully lightened with the hoe, and cleared of weeds. In the spring of the third year, the intervals are again hollowed out, and the mould thus withdrawn from them, which has been enriched by the remainder of the dung put upon the beds in the autumn of the first year, is again spread out among the plants.—This operation is performed in the same manner as upon asparagus beds.

The roots are gathered before winter. Some cultivators pull them up in the second year; but this is allowable only when the soil is uncommonly rich, and even then the roots do not attain the size or quality of those which have been in the ground for three years, and hence they are not easily disposed of.

Such is the method which, with some modifications, is usually followed in the cultivation of madder.

Some time ago I recommended to several cultivators of madder the method proposed by Schwertz, in the second volume of his "Agriculture of Belgium," page 213, and they applied it with great success; but neither Schwertz nor myself can be regarded as the inventor of this method, which had been previously recommended by a clergyman named Christ, in his "Unterricht von der Landwerthschaft," Frankfort am Main, 1781. His words are (p. 464), "When we consider the advantages presented by the method of Tull, we shall immediately see that there is no plant to which that method is more readily applicable than to madder." I cannot, however help thinking that it is dangerous in a first cultivation to remove the mould near the rows, according to Tull's method.

If I were to cultivate madder, I should proceed as follows:—The soil having been perfectly prepared and cleared, I should make furrows with the double mould-board plow at intervals of three feet, and set the plants on the summit of the ridgelet formed in this manner with the earth turned over by the plow. When the plants had grown to a certain hight, I should again pass the plow along the furrows, after having separated the two mould-boards to a somewhat greater distance. The plow then penetrating to a greater depth, would convey to the plants the mould which it raised out of the furrow. This operation I should repeat once more. Before winter, if the soil were not naturally very fertile, I should spread all over the surface a quantity of dung somewhat fermented; some of which would certainly fall into the furrows. In the following year I should again pass the same plow along the furrows so as to bury the dung, and again earth up the plants. This method would not entirely save manual labor, but would, at least, diminish it to a considerable extent. It would be necessary to hoe and scarify between the rows; and these operations heaping up the earth in the furrows, the plow would again throw it upon the beds. In the third year, if the furrows were broad and the plants sufficiently grown, the farther cultivation of the soil might be performed with the scarifier or horse-rake.

No one who has observed the effect of this mode of culture on other plants, will doubt that its success will be as great as that which Christ promises and Schwertz announces. It has the ad-

vantage of greatly facilitating the gathering of the roots, which, according to Schwertz's observations, being all in the same direction, may easily be taken up by the plow.

Madder should be exposed in a well-aired but shady situation to dry it. The best mode is to spread it upon hurdles as in a tile-kiln.

Its final preparation is not the business of the cultivator, unless he is at the same time a manufacturer. If he is not sure of a market for his madder when dried, and before it is bruised, he should not cultivate it unless he has a mill to grind it in.

Whoever wishes to plant madder in large quantities, ought to have seed-beds of his own. It would be too costly to purchase the necessary quantity of plants.

However advantageous the cultivation of madder may be when properly organized, it is necessary, before undertaking it, to consider maturely all that has been said on the culture of marketable plants in general. The culture of this plant is practicable only where there is a *superabundance* of manure. Moreover, it cannot enter into any ordinary rotation, on account of the length of time during which the crop remains in the ground; viz., for three years, or two at the least.

Dyers' Woad (Isatis Tinctoria).

The culture of this plant was at one time very common in Germany, especially in Thuringia: in the thirteenth century it was principally cultivated in the environs of Erfurt. It then formed a very considerable branch of commerce, and was a source of prosperity to many provinces and towns. But in the middle of the sixteenth century indigo was introduced from the East Indies, and in the seventeenth century its use became extended, and supplanted that of woad. The evil which ensued soon became apparent, and pecuniary pains and penalties were enacted against the use of this *devil's color*, as indigo was called. But these measures of commercial policy shared the fate of all similar proceedings—they increased the evil. Manufacturers and dyers declared that they could not exist without the use of indigo; and that a pound of the latter yielded as much color as three quintals of woad. So bad a character was given to woad, that dyers became ashamed to use it, and pretended to make use of nothing but indigo; although it is said that they employed woad in secret. From that time the culture of woad has become rare, and confined to particular localities.

But now that we are again obliged to make use of woad, cultivators are beginning to pay great attention to it; and it is probable that the art of preparing from this plant an indigo equal to that of the East will be realized and generally diffused. In that case, the culture of woad may again become profitable; always, however, under the conditions which we have laid down as binding on the culture of marketable plants.

There are two varieties of the plant called *dyer's woad*; one cultivated in Germany, and the other in Languedoc. The latter is said to be greatly superior to the former, and also capable of succeeding in Germany.*

The stem of woad grows to the hight of three feet, or three and a half feet; it is about as thick as a finger, and divides into several branches clothed with leaves. The leaves of the stem are amplexical, sagittate, pointed, slightly crenate, and tinged with blue. The flowers are yellow, and grow at the top of the stem.

Woad requires a good soil, either naturally fertile or well supplied with manure; carefully cultivated, and in good condition. The seed is sown in spring, or more advantageously in autumn, about the end of August or the beginning of September. The quantity is about four or five mezen per acre. Woad sown in autumn suffers occasionally, though not often, from the effects of winter; but its produce is much greater than that of woad sown in spring. If the plants shoot up considerably in the autumn, they are mowed; and the crop so obtained is used as fodder for cattle. In the spring it is necessary not only to destroy weeds by hoeing, but also to thin the plants in the rows, so that they may be at least a foot apart.

A great saving both of labor and of seed would be obtained by drilling and cultivating with the horse-rake.

When the leaves are about a span long, and the flowers ready to burst, the stem is cut off close to the root, and the largest leaves are stripped off. Some weeks after this, new leaves are put forth, and these are gathered in the same manner. This operation is repeated as long as the plant continues to grow. In this manner four crops are often obtained from autumn-sown woad. Some persons content themselves with three crops, in order to allow the leaves time to grow to a larger size. On a good soil, the average produce is about 150 quintals of leaves, weighed in the green state.

The portions of the plants thus gathered are washed; and as quickly as possible exposed to the sun till they are dried, or rather merely withered. It is then immediately transferred to the woad-mill, a trough in which a wheel, armed with teeth either of wood or iron, turns round and crushes the woad. When the trituration is completed, the woad thus ground is formed into heaps in the open air, and covered up to keep it from the rain. A week or twelve days afterward the heaps are uncovered, the woad broken up, and the interior of the heap mixed with the crust formed on the outside. The woad is then made up into balls, which are usually placed to dry on hurdles, exposed to the wind but not to the sun. The balls, when dry, are ready for sale. Such is the common process; but a better might, doubtless, be devised.

A circumstance connected with the cultivation of this plant, which will always alarm the cultivator, is that he is obliged to undertake the manufacture as well as the culture. Now this operation must necessarily be performed immediately after gathering, while the leaves are yet fresh, and at a time when in all rural establishments there is plenty of work for all hands.†

* See the work called: "Entdeckung der in Deutschland noch unbekannten ächten zahmen Waidpflanze, nebst Nachricht über den Unterschied dieser und der Thüringschen (Von Otto)"—Frankfort, 1794. A.

† "Vom Anbau des Wardkrautes dessen Zubereitung und Anleitung Indigo daraus zu machen."—Vien. 1788. Schreber's "Historische-physische undoeconomische Beschreibung des Waides."—Halle, 1752.

Dyer's Weld (Reseda Luteola).

This coloring-plant presents to the cultivator the great advantage of being salable without any other preparation than drying.

It thrives best on a sandy soil, inclining to the argillaceous character, highly manured, well cultivated and weeded. The seed, which is small, should be sown in August, in quantity about eight pounds per acre; it will not bear to be covered with a large quantity of earth. In the month of August of the following year, the seed ripens, and the plant begins to turn yellow; it is then pulled up, dried, and tied up in bundles, which are sold by the quintal. The seed may also be used for extracting oil.

The culture of weld requires but few details; and as an acre produces from six to eight quintals, each of which may frequently be sold for eight rix-dollars, the crop is very profitable, provided we have the means of disposing of it. Marshall, however, advises those who let land to farmers, to introduce a clause into the lease prohibiting the culture of this plant, because it is very exhausting to the soil.

Bastard Saffron (Carthamus Tinctorius).

This plant requires a soil in a state of cultivation equal to that of garden ground. The seed is sown early, at intervals of two feet; several grains being, however, sown together, in order that those plants which present the best appearance may be afterward left to grow, and the rest pulled up. The interspaces are kept free from weeds by cultivations, for which the horse-hoe is the most appropriate implement. When the flowers turn yellow, or assume a somewhat darker hue, which they do in August, they are plucked with a blunt knife, and afterward dried under cover. This operation of plucking the flowers should be performed in the forenoon, and never during the hottest part of the day. The gathering takes up more time than any other part of the culture of this plant.

The plant is left standing till it ripens; it is then pulled up, dried, and threshed for the purpose of separating the seed. This seed yields a good oil, but only in small quantity.*

THE HOP.

This kind of produce is become an object of almost primary necessity: its sale may always be regarded as certain, and the price which it fetches is sufficient to pay the interest of any sum that may have been expended on its cultivation, at the rate of cent. per cent. The culture of the hop ought, therefore, to engage the attention of every cultivator who is able to advance the necessary capital, and has brought his system of rural economy to such a degree of perfection as to furnish him with the very large quantity of manure which this cultivation requires.

There are two species of the hop; the wild and the cultivated. The former is in every respect smaller and weaker than the latter; and though it might be improved by cultivation, no one thinks of making the trial, because the cultivated hop is always easily procured. Of this latter species there are two varieties, the early and the late; the panicles of the former are larger and more aromatic than those of the latter. On the other hand, the latter produces a greater number of panicles, and is said to be much less liable to diseases and casualties. In general, however, all well informed cultivators give the preference to the early variety, especially those who can usually obtain the requisite number of laborers for gathering it when ripe; that is to say, toward the end of harvest time, at the end of August or the beginning of September.

Less careful cultivators are in the habit of mixing the two species indiscriminately in the same garden: a practice which is mischievous in every respect, and greatly interferes with the gathering of the crop. In planting a hop ground, especial care should, therefore, be taken to prevent the mixture of the two species.

The hop is a diœcious plant; that is to say, its male and female flowers grow upon different stocks. The plants, have, however, almost the appearance of undergoing a change of sex; for the females being alone available for use, are likewise the only ones from which shoots are taken. The males are always destroyed, except when the seed is intended to ripen. A few male plants, may, however, always be found in hop plantations: their existence is not easily accounted for, except upon the supposition that some of the plants have ripened their seed before the usual time.

The spot chosen for the hop-ground should be in an open situation, but somewhat sheltered from the north wind. Hop-grounds which have not a free circulation of air, are precarious. The best mode of enclosing the ground is to surround it with a ditch; a hedge may, for greater security, be planted by the side, but it must be kept low. Very dusty situations, such as the neighborhood of great roads, should be avoided.

The soils best adapted to the cultivation of the hop, are clayey sands and sandy clays, provided that they are in a proper state of fertility at the time of planting, and are afterward supplied with the quantity of manure required for continuing and increasing their fertility. On moist, argillaceous and heavy soils, the success of the plant is more precarious; but on the other hand, its produce is greater when it does succeed. Where the lower stratum of the soil is mixed with calcareous stones, but the vegetable stratum is of considerable thickness, the hop is sure to thrive well. Fertile soils, which have been long used as grass lands, kitchen-gardens, or orchards, and have always been plentifully dunged, are the best that can be chosen for the formation of hop-grounds.

When a piece of land is to be prepared for growing hops, it is a good plan to cultivate a hoed crop on it the year before, unless we intend to plow it often and carefully during summer. Even if the land has been manured for the hoed crop with eight four-horse wagon-loads of stable-manure per acre, it will still be necessary, after gathering that crop, to manure again with at least ten wagon-

* Dallinger's "Œconomische technologische Abhandlung über den Safler und Waidbau." Neue Auflage, 1805.

loads per acre: this latter quantity may be either spread over the surface and left there, or buried with the plow. At the beginning of spring as soon as the soil is somewhat dried, it must be turned up to a considerable depth, either with the plow or the spade.

The hillocks on which the plants are to grow, should be at least four feet square: some persons place them six or eight feet apart. A pole is set up in the place which each of these hillocks is to occupy; a circular trench, four inches wide and five deep, is dug around it at the distance of six inches, and the plants are set on it in such a manner as to leave from three to five of their eyes above ground. Strong and healthy plants must be selected for the purpose. The trench is then filled up with the mould taken out of it, care being taken to press the earth close to the plants, and form a little mound of earth round them, so that that the buds may be completely covered. At the end of a few weeks, sooner or later, according to the state of the weather, the young plants will begin to grow. As soon as weeds make their appearance, the whole ground must be hoed, and the spaces between the plants weeded. This is the time for fixing the poles which are set in holes previously made for them with an iron fore-stake. To these poles the young plants are tied; only, however, the principal shoots; the others are cut off. The former soon begin to climb up the poles, twisting themselves round in a spiral direction. If necessary, the false shoots are again cut off.

If, instead of forming the plantation with young plants which have just taken root, we make use of grown plants taken from an old hop-ground, the planting may be deferred till autumn. A tolerably good crop will then, in all probability, be obtained in the following year.

The hop is earthed up on St. John's day, the mould being taken from the interstices and a little hillock formed round each pole. In performing this operation, particular care must be taken not to touch the roots of the hop. As the produce is very trifling in the first year, many cultivators plant other vegetables, such as cabbages and beet root, in the interstices. The first year's crop is, indeed, so inconsiderable, that many persons abandon it altogether, and cut off the tops of the plants to strengthen them.

The hillocks are manured after this first crop; five large wagon-loads of dung per acre are used for this purpose. The earth forming the hillocks is depressed a little, and the dung then placed upon it. In March, the portion of dung remaining on the hillocks is removed, and buried in the intervals: the poles are also restored to their places. The quantity of dung must be regulated according to the wants of the soil: an excess of it might induce disease in the plants. The superabundant germs, which in spring form a very agreeable dish, are removed. Six or seven stems only are allowed to shoot up, and are again tied to the poles; in other respects the mode of proceeding is the same as that of the preceding year.

The principal difficulty which some cultivators have to contend with, is that of procuring poles. These poles must be from fourteen to eighteen feet long at the least; for the first year, however, shorter ones may be used.

Some persons set up two or three poles on each hillock, and distribute among them the stems of the plants which grow upon it. The cost of the poles forms the principal part of the expense of forming a hop-ground; and various methods have been devised for reducing it. Thus, it has been recommended to make the hop climb round poplars with their heads lopped, as vines grow in some parts of Italy. Hops will certainly be obtained by this method, but the crop will be inferior both in quantity and quality; moreover the plants will be more subject to disease; so that the cultivation of the hop by this method will not, in the end, be more profitable than when poles are used. The trellis work which has been proposed as substitute for poles, is likewise not more advantageous.

As soon as the hop is ripe, which may be known by its assuming a brownish tinge, becoming hard and firm, and acquiring a pleasant aromatic odor, the gathering should be commenced without delay. The early hop is usually gathered about the beginning of September; and the late, toward the end. The stems are cut close to the ground, and carried away with the hops which grow upon them. The picking is performed either on the ground or under cover. The former method requires dry weather; and in order to profit by such weather, the greatest possible number of laborers must be employed. The poles are placed, two at a time, on a kind of scaffolding, and under them is hung a cloth to collect the hops as they are picked. The work-people occupied in picking the hops, chiefly women and children, are scattered round the scaffolding; while others at the same time bring new poles, and remove those which have been picked. When the cloth is full, the hops are thrown into a large sack, in which they are carried to the drying place. If they were left in the sacks they would soon become heated.

If the hop is to be dried within doors, the poles are drawn out of the bundles of hop plants which enclose them; the plants are then tied lightly together and carried under cover, where they are picked as quickly as possible. The former method is doubtless to be preferred, when a sufficient number of hands can be obtained; for hops which are housed before they are picked, are apt to acquire a bad taste.

The hops, when picked, should be spread out in a thin layer on the floor of an airy barn, and turned every day till they are perfectly dry; or they may be placed on a stove which is well set and burns without smoke. The latter method is the more expeditious, guards against all loss, and is beneficial to the hops. The stove is covered with a horse-hair cloth, on which the hops are placed in a layer, varying in thickness from six to twelve inches, according to their greater or less degree of moisture and ripeness. The heat of the stove must be well regulated, constant care being taken not to keep it too high. When the peduncles of the hop break with facility, and the follicles fall off, the drying is complete; eight or ten hours are required for bringing the hops to this state. This mode of drying doubtless requires some experience and practice to enable the person who conducts it to adopt and maintain the exact temperature required. It is indispensable to keep a man constantly engaged in this work. The hops having been thus dried, are carried to a room prepared for them, and there left for six or seven days, in order that they may regain a small quantity of moisture before they are packed up.

After the hops have been dried by either of these methods, the cultivator either has them carried to the warehouse intended for keeping them, and there packed closely by treading them under foot; or they are put into bags for sale.

In order to bag the hops, the mouth of the bag is attached to a frame, and a handful of hops is attached to each of its lower corners to give greater hold. The hops are then put into the bag by degrees, and pressed closely, either with the feet, or with a heavy pestle. When the bag is full it is detached from the frame, a handful of hops is attached to each of the upper in the same manner as to the lower corners, and the mouth sown up with pack-thread. The quantity put into the bag may vary from 150 to 200 lbs. Hops packed in this manner will keep for a long time; whereas, if they are left unpacked, they will lose their glutinous surface and aroma.

The quality of the hop is judged of according to the glutinous character of its surface, its aromatic odor, the farinaceous substance with which it is speckled, and its color, which should be a bright yellow.

As soon as the gathering is over, the poles must be taken care of by placing them under cover, or tying them up in bundles, 30 or 40 together, and leaving them in the open air.

The produce and value of hops are very variable. The best hop-ground sometimes yields scarcely a quintal per acre; while in other seasons, it will produce from fifteen to eighteen quintals. The price sometimes falls to 12 rix-dollars per quintal; at other times, rises to 70 or 80 rix-dollars. Hops yield a very large profit when kept from a year of plenty to one of scarcity: but this is the business of the speculator, rather than the cultivator.

The expenses of cultivation are no less difficult to estimate; for they depend upon the locality: nothing, therefore, can be said with regard to the average net profit and advantages of this branch of cultivation. Particular cases are known in which the net profit per acre has amounted to two or three hundred rix-dollars in a year; while, in other cases, the receipts have been far from sufficient to meet the expenditure.

In fact the success of the hop is mainly dependent on the weather, and the absence of certain accidents to which the plant is exposed. The care bestowed on the formation and culture of the hop-ground may indeed obviate casualties to a certain extent, but cannot utterly remove them.—A warm summer, with moderate winds from the south and south-west, and not much rain, is favorable to the hop: but, in wet seasons, particularly when the wind blows much in summer from the east and north, the hop is sure to fail. When a hot sun follows rain or fog, or sultry days alternate with cold nights, the hop suffers considerably, even when these occurrences take place only at the latter end of the summer. In spring the hop suffers from the attacks of an insect of the flea kind; in summer, from various kinds of flies and lice, but especially from *honey-dew*, which, at this time, shows itself after cold nights, and attracts insects: nothing but a heavy thunder-shower can save the hop from these enemies. In the last stage of its growth it is exposed to mould and honey-dew, especially when the hop-ground is in a low and confined situation. In the midst of all the dangers and enemies with which the hop is surrounded, its success is, in a great measure, a matter of chance.

TOBACCO.

The extensive use which is made of this plant in all countries of Europe, where it is not prohibited or restricted from financial motives, has caused its cultivation to be preferred to that of other marketable vegetables; the profit arising from it varies according to the influence exerted by naval warfare upon commercial transactions.

It has been found, however, that proprietors of large estates derive greater advantage from transferring the actual cultivation of the plant to small cultivators of active and industrious habits, than by having these operations executed at their own expense. Accordingly, when the soil has been completely prepared and properly manured for the growth of tobacco, it is sometimes let out to these cultivators either at a fixed price, or with an understanding that they are to have part of the produce. This last method is the one most generally approved, because it induces both planter and proprietor to take equal interest in the success of the crop. Hence, in all districts where the culture of tobacco is known, there has arisen a class of persons called planters, who, during the summer months, employ themselves solely in the cultivation of this plant. Where the soil is bad, the proprietor and the planter share the produce equally between them: but when it is very good, the proprietor gives up only two-fifths of the produce. The proprietor furnishes the soil, manure, preparatory plowings, and drying-shed: the planter performs all the rest of the labor, and rears the plants; the proprietor supplying wood and dung for the seed-bed, and lending his teams for housing the crop. The expenses of sale and carriage to market are borne in common. But the families of planters who engage in these undertakings must be possessed of some little property, and be able to maintain themselves till the time arrives for disposing of the crop. The planter must also derive some profit from the undertaking, in addition to the remuneration for his labor.

The average produce of tobacco may be reckoned at about 8 quintals per acre; and, as a quintal sells for 5 rix-dollars, the produce of an acre may be valued at 40 rix-dollars: of these the proprietor takes 24, and the planter 16. A clever and industrious planter can, with the help of his family, cultivate 12 acres: he can, therefore, gain 192 rix-dollars during the time that he devotes to the planting, culture, and drying of the plant: he is, however, obliged at the time when there is the greatest quantity of work in hand, to employ a few assistants, whom he pays out of his own pocket.

Tobacco leaves the soil in a good state of preparation for other produce: it completely supplies the place of fallowing. According to general observation, the crop which succeeds it is in no respect inferior to that which comes after a dead fallow, provided the tobacco-soil has received four wagon-loads of dung per acre more than the fallow. This dung forms the chief item of expenditure that must be laid to the charge of the tobacco-crop; and for this reason the culture of tobacco is most practiced in places where dung can be obtained at a low price.

A point of great importance for carrying on this cultivation on a large scale is the possession of

spacious drying-sheds. Every barn, cart-shed, and stable is made available for this purpose. Tobacco does not even suffer in quality by being hung up in stables above the cattle.

Many operations in the culture of tobacco might, doubtless, be greatly expedited by the use of the horse-hoe; but as there are also many parts of it which must be performed by manual labor, at stated times, and with considerable accuracy, it seems best, on the whole, for the great cultivator to leave the entire course of operations in the hands of the planter.

I shall not, therefore, describe the minor operations in the cultivation of tobacco which are the business of the planter, but only those which are within the province of the great cultivator.

Various species of tobacco have been recommended for cultivation; but the ordinary Virginian tobacco (*nicotiana tabacum*) has obtained the preference before all others. That which, under the name of common green tobacco (*nicotiana rustica*), has been so much extolled by some persons, has not been found successful in the long run. Cultivation has, however, produced several varieties of the former species, particularly one which grows to a large size, and another much smaller.

Tobacco prefers a light soil; it thrives better on a sandy than on an argillaceous soil. Sandy clays agree with it best; but it is also successful on soft clays, which contain a large quantity of humus. But to produce a perfect and plentiful crop, the land must be rich in ancient humus; and must, besides, have been recently fertilized with some sort of manure. The best tobacco is that which grows on clearings, especially if the turf which covered their surface has been burned upon them; and still better if the wood which grew upon them, or wood brought for the purpose, has also been consumed on the spot and reduced to ashes. It is, certainly, to this treatment, rather than to difference of climate, that we must attribute the great superiority of the American tobacco, which is grown not on land recently dunged, but, on the contrary, after ten or twelve crops, all obtained without the use of dung, on the rich and burnt clearings of Rhode Island. Our manufacturers are also aware that the leaves of tobacco grown on land of this description are far preferable, both for sweetness and scent, to those produced from land recently dunged. In commerce, however, they will not admit this fact, from fear of having to pay a higher price for the former—a price which certainly ought to be, and will be obtained as soon as the superiority of that description of tobacco becomes generally known.

The tobacco next in value to that just mentioned, is that grown on a soil rich in humus, after manuring with lime, marl, or ashes; manures which would have but little effect on the plants if the land were poor and exhausted. The growth of tobacco is usually forced with dung, a mode of treatment which always produces that acrid taste and unpleasant odor which manufacturers have sought in vain to remove by various modes of preparation. But as this kind of tobacco is most commonly met with in commerce, it must certainly find purchasers in the market.

Land is prepared for tobacco in the same manner as for other weeded crops. The stubble is cleared off in autumn. The dung is carted and spread as much as possible before winter. In spring, this dung is buried by a superficial plowing; and then, a little before planting, the land is plowed deeply, in order to lighten the upper stratum of the soil.

The success of tobacco mainly depends on planting as soon as possible: in the month of May, if circumstances permit. For this purpose plants of sufficient strength must be ready at hand, and the soil must previously have been prepared in the manner required.

The remaining treatment, which is the business of the planter, does not, as already observed, come under our present observations. It may be found described at length in various manuals of Agriculture.*

In countries where the practice of committing the plantation, after culture and gathering of tobacco, to the hands of planters, in consideration of their receiving a part of the produce, is generally adopted, the conditions of this compact are already defined. More detailed instructions on this matter may be seen in the work of Count Podeivils, entitled, "Wirthschaftserfahrungen," part i. page 75. In countries where this custom is not already established, the proprietor must be content at first with making a somewhat disadvantageous agreement: but planters will soon become more moderate in their demands when they learn by experience the advantage which they may derive from such an undertaking, on a soil adapted for the growth of tobacco, and properly manured.

As the carriage of tobacco is easy, it is unwise to allow a long road to deter us from taking it to a market where a large assemblage of buyers will ensure high prices. The price of tobacco usually rises in spring and summer; but as it then contains a smaller quantity of moisture, its weight is likewise diminished.

The stems of the tobacco-plant have been advantageously used in the manufacture of potash; for they contain a large quantity of alkali. If the ground is to be sown in autumn, these stems must be taken up; but if the tobacco is to be followed by a spring crop, they will be sufficiently decomposed during the winter to prevent them from interfering with the spring plowing: and it is certain that they restore to the land a portion of the nutritive matter which the tobacco has absorbed from it.

Some cultivators have thought it advisable to leave standing a larger number of stems than they require for obtaining the necessary quantity of seed, and to employ the surplus seed for obtaining oil. The seed of tobacco yields a fair proportion of oil, of tolerably good quality.

CHICCORY.

Of all the plants which have been proposed as substitutes for coffee, and which, when roasted and steeped in boiling water, yield an infusion resembling coffee, chiccory is the only one which has maintained its ground. It has been used in this manner for thirty years, even when the price

* Also in the following works:—"Kling; der Tabaksbau für den Pfälzischen Landsmann," 1798. "Kerge; Unterricht zum Anbau des Tabaks," Breslau, 1773. "Rieben; Anleitung zum Tabaksbau," Dresden, 1789.—"Christ; Anweisung zum einträglichsten Tabaksbau," Frankfort, 1799. "Traite; complet de la culture, fabrication et vente du Tabac," Paris, 1791. A.

of coffee has been low; and has always yielded considerable profits, both to manufacturers who prepare it in large quantities, and those who cultivate it in their neighborhood. In countries where this plant has been cultivated, land on which it is grown has been known to give a return of 16, 20, or 24 rix-dollars, without previous manuring or preparation.

Chiccory requires an argillaceous soil mixed with sand; light, deep, and rich. The soil must also be turned up to a considerable depth; an operation which is performed with the spade in districts where there are no plows made to go deep into the ground. It is usual to manure for this crop with very rotten cow-dung: a small quantity only is used, as too much manure causes the roots of the chiccory to throw out a great number of filaments, and to acquire an unpleasant flavor. Chiccory is sown in the spring—generally broadcast, like carrots. Some persons, however, who raise the plant in large quantities, have obtained very good results by drilling it, and cultivating with the horse-hoe; they have thus saved a great part of the expense of weeding and thinning the plants.

The haulm may, according to some persons, be cut at the end of July or the beginning of August, without injury to the roots. A plentiful supply of fodder is thus obtained.

The roots, carefully taken up with the spade or fork, may be sold while fresh in the neighborhood of the chiccory works; otherwise it is necessary to cut and dry them.

It is of importance that all the roots be carefully removed from the soil; as they will otherwise shoot up again like weeds, spread very rapidly, and be difficult to eradicate. It has also been remarked that chiccory exhausts the soil to a great degree; and that good lands have, by the production of repeated crops of this plant, been so much impoverished that a large expenditure of labor and manure has been required to restore them to their pristine fertility.

Chiccory has been also cultivated as a fodder-plant, first in France and afterward, upon Arthur Young's recommendation, in England. The principal crop is not obtained till the second year: it is said to be more abundant than that afforded by any other herbage-plant. In the trials which I have make of this plant, I have certainly obtained a very plentiful crop, which was eaten with avidity by horned cattle, and had a good effect on the quality of their milk. The chiccory afterward put forth its flower-stalks with great vigor, without producing new radical leaves. The stalks yielded but an insignificant produce, which was rejected by the cattle: I am, therefore, of opinion that chiccory is not adapted for this purpose. The English, and particularly Arthur Young, have used it chiefly as pasturage for sheep, and found it very useful in this respect; for a small extent of chiccory ground will fatten a large number of sheep. When the plant is continually cropped by the sheep, it must necessarily shoot forth close to the ground; it will then, undoubtedly, go on for a longer time, producing radical leaves. The high stems would certainly not afford proper nourishment for these animals. Chiccory may be used in this manner for a number of successive years. I can say nothing about the manner of ridding the soil of it: I have always found it very troublesome in this respect. The preceding observations must, therefore, be regarded rather as a notice than a recommendation of chiccory.

CARRAWAY (CARUM CARUI).

This is a biennial plant; it must be sown early in spring, and does not produce seed till the following year. It therefore occupies the ground for two years; and as it cannot be successfully cultivated excepting on the richest soils, the rent of the land for two years must be laid to its account, unless some other plant can be cultivated on the same ground during the first year, and thus made to pay part of the rent.

Where the culture of carraway is pursued according to the most approved method, as, for example, in the neighborhood of Halle, the plants are raised in a seed-bed, which is often made and sown in autumn, but more generally at the beginning of spring. The land is prepared for this crop in the same manner as for weeded crops.

The planting takes place on St. John's day. Rows of carraway are planted alternately with rows of cabbage, turnips, or beet-root: the after-culture is performed with the hoe. The last-mentioned plants are pulled up in autumn, and carraway left alone in the ground. In the following spring, one or two cultivations are performed with the hoe. The seed ripens about St. John's day. The plants are then either reaped or pulled up.

Some cultivators sow carraway on the ground on which it is to remain, after having prepared the soil in the proper manner: they sow the carraway either alone, or alternately with carrots, poppies, flax, or even spring-corn: they then weed and thin the plants. In autumn, or the following spring, they manure the land either with compost or poultry dung, and gather the crop without transplanting.

I cannot pretend to decide upon the comparative merits of these two methods: this can be done only by cultivators who have tried both for a series of years, and have been at the pains of calculating the outlay and return. The method of transplanting has the advantage of allowing a longer time for cleaning the land well.

Carraway cannot be grown successfully, excepting on strong first-class wheat land, very rich black clay, or, at all events, on land of average fertility, well situated, and cultivated like a garden. On such lands it rarely fails, and always stands the winter well.

In gathering carraway, the same precautions are necessary as in gathering colza, to prevent the seed from being shed. It is either reaped or pulled up, and then carefully removed: sometimes, however, it is threshed on the ground.

The price of carraway is, in almost all countries, high enough to render its cultivation profitable. But the cultivator cannot trouble himself with the minute details of sale; he must, therefore, give up the greater part of the profit to the dealer.

A large consumption in the brandy distillery might render the culture of carraway very profitable.

COMMON FENNEL (FŒNICULUM VULGARE).

Fennel is cultivated and treated in the same manner as carraway. Its principal use is in pharmacy; but confectioners and liqueur merchants also employ it.

ANISE (PIMPINELLE ANISUM).

This plant is an annual; it is sown in spring, and ripens at the beginning of autumn; it is usually grown among carrots, and treated in the same manner.

I say nothing about the culture of other plants whose roots are used in pharmacy, partly because I have no actual knowledge either from my own experience, or from observation of the culture of many of them, such as *Saffron*, *Liquorice*, *Camomile*, and *Mint*, all of which are but little suited to our climate; partly because I consider that many plants of the same class, such as *Rhubarb*, the *Rose*, and *Lavender*, belong more properly to the province of the gardener. The raising of these plants as field-crops may, however, be advantageous on good soils and under favorable circumstances. In carrying on the cultivation of such plants, the safest plan is to make bargains beforehand with wholesale druggists, and to assure ourselves, by trials on a small scale, of the success and quality of the plant, the cultivation of which we are about to undertake. We now proceed to the

CULTURE OF FODDER-PLANTS.

Under this denomination we shall include vegetables which are also used as food for man, but are grown on large extents of land, chiefly to be employed in feeding cattle.

We shall first speak of those which are most advantageously cultivated with the horse-hoe, provided attention be paid to what has been previously said of this mode of cultivation.

The Potato.

It is about 265 years since this plant, now so completely a necessary of life, was first introduced into Europe. It was brought from Santa Fé, by John Hawkings, in 1565. At that time it was solely cultivated in gardens, as an object of curiosity, and eaten as a luxury.

It was not till 1623 that Sir Walter Raleigh introduced into Ireland the use which was already made of it in Virginia. It was, however, pretty well known in Italy as early as the year 1588, and was probably introduced at that time into Germany, though it did not become well known in the latter country till about the year 1710. After that time it was regarded as a common plant, and cultivated in gardens; it was, however, more frequently seen on the tables of the rich than on those of the poor. In 1760, toward the end of the Seven Years' War, the use of the potato became more general; but in most countries, its cultivation in the open field was still regarded as extraordinary, extravagant and inconsistent. It was not till 1771 and 1772 that the practice of cultivating the potato as a field crop began to acquire supporters; but at that time all the grain crops failed, and the famine which ensued led to the discovery that proper and sufficient nourishment might be derived from those very potatoes which had hitherto been regarded only as a luxury, just as well as from bread. Still the cultivation of this plant did not exceed the wants of man himself. It was not till a later period that the practice of giving the refuse and surplus to the cattle began to creep in. But it was thus gradually discovered that potatoes might be advantageously cultivated as food for live stock. Bergen, in his "Introduction to the Management of Live Stock," ("Anleitung zur Viehzuct"), was the first to recommend the practice of this cultivation on a large scale, and the use of a kind of horse-hoe to save manual labor. At the present day it appears scarcely credible that the extreme utility of this plant should have so long remained unknown, and that so much difference of opinion should have existed on the propriety of raising it on extensive tracts of land.

There is no plant to which I have paid greater attention than to the potato. Even before I entered upon the practice of Agriculture, my attention was excited by the innumerable varieties which were produced by raising it from seed. I treated it in various ways at that time, merely with a view to vegetable physiology, my object being to discover whether the distinguishing characters of these varieties were due to the nature of the soil, or to the mode of fertilizing it. Since that time I have, in raising the potato, tried all the methods proposed by others, as well as those which I have myself devised. As far as the quantity of produce is concerned, the results of various modes of planting and cultivating have shown but little difference, unless, indeed, the cultivation were altogether badly arranged or neglected. The quantity of produce was found to depend on the soil when the species cultivated was the same. But the manual labor required, and, consequently, the net profit, varied considerably. I have done my utmost to reduce this manual labor to the smallest possible amount without sensibly diminishing the produce; for, in the raising of potatoes, the rent of land is much less considerable than the expenses of cultivation. I will venture to assert that I have attained this object more nearly than any one else, and that I have found myself nearer and nearer to it at the end of almost every successive year. I therefore beg those persons who have read my former works, and the observations which I have made on the culture of the potato in the first and third volumes of my "English Agriculture," in my "Anmerkurgen zu Bergen's Viechzucht," and in the "Annals," to consider such observations as the result of my apprenticeship, and those which I am now about to make, as more complete and matured.

In order to make some sort of classification of the innumerable varieties of the potato, we must confine our attention to the most useful part—the tuber. It is true that the leaves and flowers appear to bear some relation to the form of the tuber; but the particular examination of them belongs more properly to the *botanical cultivator*. We cannot expect that this examination will be undertaken either by the mere botanist or the mere cultivator.

The skin of the potato is, in some varieties, of a dark color, approaching almost to blackness; in

others, of a reddish violet, which varies to pale, brownish or yellowish red; in others, again, of a whitish yellow.

The color of the flesh is sometimes yellow; sometimes whitish, or perfectly white; and sometimes slightly tinged with red.

The several varieties of the potato have different times of arriving at maturity; that is to say, at the state in which the tubers are detached from the maternal plant, and the latter dies. There are some that can be cultivated more than once in the same summer, and on the same land.

But the points of difference which we have chiefly to consider, relate to the consistence of the potato and the quantity of starch contained in it. Some varieties are very spongy, their interstices are filled with water, their specific gravity is small, and they contain but a small quantity of nutriment in a given bulk.

The flavor of some potatoes is very agreeable; of others, very disagreeable. Some improve by keeping; others are best when fresh gathered.

Some cook speedily and burst; others resist the action of steam and hot water for a long time.

Some varieties require a dry soil, becoming quite watery and hollow in the middle when grown on land which contains much moisture; they also secrete water in their cavities. Others, on the contrary, remain very small, and are scarcely worth the expense of cultivation when sown on a dry soil.

Some put out long filaments into the soil; others press their tubers so closely together, that they show themselves above ground.

Some potatoes thrive particularly well on marshy land; others perish on it, and thrive on an argillaceous soil.

All these particulars must be taken into account, when a selection is to to be made of varieties for cultivation. The culture of a new variety should never be undertaken on a large scale, till a proper trial has been made of it.

The amount of produce of each variety must be taken into consideration, but the value calculated according to the quantity of nutritive matter contained in it. This may be judged of approximately by the sensation which the fleshy part of the tuber produces when applied to the tongue; or more accurately, by cutting the tubers in pieces, drying them, and comparing their weight in the dried state with what it was before; but an accurate estimate is only to be obtained by chemical analysis. Great bulk is by no means desirable, if it be not attended with increase in the quantity of starch; for the potatoes then take up more room, although their intrinsic value remains the same; and they are more likely to be spoiled. In other respects, when potatoes are cultivated for sale, the choice must be directed by the taste of purchasers, and the price which they will fetch in the market.

As to the nomenclature of potatoes, the confusion which exists both in England and Germany, in the names even of the most ordinary varieties is so great, that to avoid misunderstanding I must altogether refrain from speaking of it. Under the denominations of English, Dutch, Rhenish, Holstein, and Polish potatoes, varieties totally different are indiscriminately designated in different places.

I used formerly to make frequent attempt to raise potatoes from seed. This method is interesting to an amateur gardener. He may, perchance, obtain the merit of giving rise to a new variety of good quality; but it is not economical; for, unless it be tried on hot-beds, the tubers will take too long a time to attain their full size; and, what is more, the result will almost always be a mixture of varieties difficult to distinguish; and even if it preserve its identity, presenting an inconvenient assemblage of different qualities. The different varieties may be kept separate, because they germinate and ripen at different times. These observations are not meant to apply to the cultivation of the potato in gardens.

Potatoes will grow on soils of all descriptions, and in favorable weather will yield a good crop, even on moving sand, provided that it has been well manured. On a stony soil, well prepared, and lightened with dung, containing straw, the success of the potato is certain; though a sandy soil is best adapted to it.

On clearings and marsh lands, provided the soil has been well drained, and especially if the turf has been burnt upon it, potatoes thrive particularly well, and sometimes yield a very large produce.

The cultivation of the potato as a field crop has hitherto taken place chiefly on the fallow-field, and it has been proved that, when properly executed, this cultivation fulfils all the advantages of fallowing. The produce of the autumn grain which follows the potato crop is, however, somewhat diminished; this fact has been established by conclusive experiments, and is uncontradicted, excepting by a small number of particular cases. As there is usually an objection to the sacrifice of the autumn grain which succeeds the fallow, many of the ablest followers of the three-field system have resorted to the method of setting their potatoes on the spring corn field, giving them perhaps a little dung, following a crop of peas, which doubtless thrive remarkably well in that situation: the rotation is then recommenced.

It is generally admitted that potatoes grow larger after recent manuring; they will, however, yield a good crop, even when raised as a second or third crop: but the soil will then be greatly exhausted. I have never even thought of asserting that potatoes do not impoverish the soil; on the contrary, I have stated that they do so (English Agriculture, vol. ii. p. 237): they do not, however, exhaust the resources of the establishment in general, but increase those resources to a considerable extent, *if they are given as food to the cattle.*

On strong land, fresh dung mixed with straw is most beneficial to potatoes, and the more so in proportion to the closeness of its contact with them: it should, therefore, not be carted and put into the ground till just before the seed-time plowing. But for light soils, the dung must either be in a more advanced stage of decomposition, or it must be mixed with the earth by several plowings.

Very healthy potatoes are also produced by the use of other active manures, such as scrapings of horn spread in the furrows at the seed-time plowing, rags of wool, and the refuse of the tan-yard. Turning sheep on to the field after the potatoes have been set, is likewise very efficacious in promoting their growth, but it gives the tubers a bad flavor. There is also a limit to the degree of cultivation proper for potatoes: if it be surpassed, the haulm becomes excessively large, and falls upon the ground; the number of tubers is then much diminished.

In setting potatoes, it is necessary to select the most healthy and vigorous tubers; not such as have already been deprived of two or three of their buds, because the most vigorous buds are always the first chosen. Especially must those be rejected which have been much exposed to cold, even though they should not have been injured by frost. Potatoes grown in pits, mounds, or hollows, where frost has penetrated and destroyed a portion of the tubers, are very uncertain in plantations: I am sure of this from my own experience. They either do not shoot up at all, or produce but feeble plants; great care should, therefore, be taken to preserve those which are intended for setting.

I am aware that many cultivators have obtained abundant crops of large potatoes by planting none but small tubers: nevertheless, I prefer setting those of large and average size, especially for certain varieties. Small tubers have not the same power of germination as large ones, and often do not germinate at all; whereas, those of large size may without injury be cut in halves. When circumstances are otherwise favorable, very strong plants are often obtained by setting mere cuttings of potato containing a single eye; or even the eye by itself; or, lastly, the mere skin. But on heavy land which has not been well pulverized, as well as on a sandy soil, there is great danger of failure, if, after setting or during germination, the weather should be unfavorable to the formation of the plant. To ensure success, this plant must by means of its feeble roots immediately seek for nourishment in the soil. It must not encounter a hard piece of ground; for, as it derives no nourishment from the maternal plant, it would then dry up and perish. I therefore abandon this method altogether, although I formerly recommended it: it succeeds very well in gardens, but is very uncertain for potato crops grown in the open field. The same may be said of shoots planted alter having been cut from growing plants.

There will always be a difference of opinion touching the expediency of setting potatoes close together, or far apart; for the decision of this matter depends upon adventitious circumstances: but repeated trials accurately described by the estimable J. N. Schwertz, in the "*German Agricultural Gazette*." seem to show that the quantity of produce is, to a considerable extent, in proportion to that of the sets. The practical results of these trials are as follows:

1. The amount of *net* produce, deduction being made for the quantity of potatoes used for setting, bears a tolerably exact proportion to the latter quantity—that is to say, that one who sets a larger quantity of tubers, will usually obtain a more abundant crop, than one who sets a smaller quantity.
2. Fine large tubers produce not only larger potatoes, but also a greater number of them.
3. The degeneracy often observed in potatoes apparently results from the use of unhealthy plants for setting.
4. Small tubers, and those which are destitute of of buds, cannot by any means be recommended for setting.
5. When potatoes of medium quality are planted, it is better to set them whole: but when the tubers are very large, the halves will be found sufficient, provided, however, that they are set rather closely in the rows.
6. It is not advisable to cut a potato into more than two pieces.
7. It is better to set the tubers one by one and close together, than to put a number of them into the ground together, particularly when all the labor is performed with the plow, and no cultivation is given with the hand-hoe.
8. It is not advisable to plant mere buds: they often fail.*

I give these principles as being in an accordance with my own experiments made on the large scale. with the exception, however, of the first. It does appear, from actual experiment, that the quantity of produce is in proportion to that of the potatoes put into the ground. The author deduces a result by dividing his plantation into two parts. In one of these he places the trials in which the quantity set amounted to more than 1.254; and in the other, those in which this quantity was less. In the former, the net produce of each row was 16·81; in the latter, only 15·41. These two results are in the proportion of 1000 to 917. The loss in the latter is, therefore, 8⅓ per cent: but the difference in the relative quantity of the sets is much greater. Then again, among the trials included in the latter division, there are several which ought not to be included in the comparison: where, for example, the sets consisted of buds, or mere eyes, or handsful of very small scattered shoots, all of which gave but a very insignificant produce. If we take into account those trials only in which good potatoes, or cuttings of them, were set at intervals of 1, 2, 3, or 4 decimetres, it will be found that the difference is very small, not exceeding 2½ per cent.

I am willing to admit the existence of this difference, and even of one of five per cent., if the potatoes are set in one part of the rows at eight inches and in another at twenty-four inches distance: so that the quantity of sets used for the former shall be three times as great as that used for the latter. The quantity obtained from the half in which the potatoes are at the greatest distance apart will not amount to more than ninety-five bushels beyond that of the sets, while the produce of the other half will amount to one hundred bushels.

On the other hand, the practice of setting at greater distances is attended with the following advantages, in field-cultivation.

1. Potatoes, especially those fit for setting, fetch a much higher price in spring than in autumn, which is the time for gathering; the keeping of them occasions both trouble and risk, and there is always a portion spoiled. Suppose that the difference in the two prices amounts to one-third only

* "Landwirthschaftliche Zeitung." 1809. Seite, 568.

of the greater, or that a scheffel which in autumn is worth eight groschen costs only twelve in spring. The increase in price of these eight scheffels amounts to thirty-two groschen. The five scheffels obtained from the crop amount to forty groschen, so that the profit is reduced to eight groschen.

2. Setting at greater distances occasions saving of manual labor.

3. When the plantations are laid out in rows in all directions, and the distances between the rows wide enough to allow the plow to pass crosswise, almost all the manual labor which would otherwise be required to weed the interspaces is saved.

4. These plowings are much more efficacious in cleansing, pulverizing, and aerating the land, than they would be if performed in one direction only. Dog's-grass in particular, which multiplies so rapidly between continued lines, is entirely destroyed by this treatment; so that the object of fallowing, one of the principal ends of the culture of weeded crops, is completely attained. I say nothing about the effect produced on the potatoes themselves by cultivation on all sides, since we have admitted for argument's sake, that those which are cultivated on one side only yield the greatest increase.

5. The gathering of potatoes is performed with far greater ease and dispatch when they grow on separate hillocks, than when they are arranged in continuous lines. My laborers are more willing to raise potatoes planted singly, for the fourteenth part of the produce, than for the tenth, when they are planted in rows; for a man can raise eighteen scheffels of the former in a day, whereas he will not be able to raise more than ten of the latter, even though they may have been cultivated with the same care. This saving of time in taking the crop is of great importance.

Such are the reasons which induce me to prefer the method of setting potatoes at moderate distances, and arranging them in lines in all directions. I admit that when this method is adopted, a somewhat larger extent of surface is required for the production of a given quantity; but the great saving of labor, and the excellent preparation of the land which it affords, are of much greater importance. Nevertheless, the case may be different with regard to those who have but a small quantity of land to devote to this description of produce.

In adopting this method, it is also necessary—

1. To employ in setting the potatoes none but steady and intelligent laborers, who will not omit to set them in any place where they ought to grow.

2. To set none but very healthy potatoes.

3. To prepare the soil in such a manner that the germination of the plants shall not be hindered.

Any one who is either unwilling or unable to get these conditions fulfilled, will do better to set his potatoes more thickly, or in pairs; otherwise, a plantation thus formed will be likely to contain a great many vacant spaces, and considerable loss will be the result.

In setting potatoes regard must be had to the state of the weather. In this country I never plant them till the soil has become heated; and I have always observed that the potatoes set last were the first to come up. I have planted them with success till the beginning of June; but I endeavór to get the setting finished toward the middle of May. If it be desired to plant them later, they may be previously made to germinate in a warm place. If the soil contain ever so small a quantity of clay, it is absolutely necessary to defer the planting till it is perfectly dry, and no longer adheres to the implements.

As early as possible in autumn I break up the soil to the depth of two inches lower than before, and then pass the harrow over it. In winter the dung is carted and uniformly spread. At the beginning of spring, this dung is buried by a light plowing; and the harrow passed over before the seed-time plowing. I like to have a portion of the manure brought up to the surface by this operation, because a greater quantity is then collected around the roots of the potatoes.

I have only once tried planting with the spade, along a cord on which the distances were marked by knots; this was my first essay of the mode of planting in squares. If I had not found out another method, the tediousness of this one would have wearied me.

The potatoes are set in furrows traced with the plow, and the mode of proceeding is as follows:—

By means of the *marking-plow* or furrower, already noticed, lines or small furrows are traced at right angles or obliquely, to the direction which the plow is to take. Five persons are then stationed at equal distances on the line of the plow, each having assigned to him the space which he is to plant. One plow traces the first furrow, which is immediately set with potatoes. Two other plows then follow, and the potatoes are set in the furrow traced by the third. It will be understood that the persons who set them have to go from one side to the other, each one keeping within his allotted space. Each potato is set at the point of intersection of the line traced by the marker, with the furrow formed by the plow. It is of importance that the potatoes be set as close as possible to the perpendicular side of the furrow, and not on that where the slice has been turned over; for, in the former position, the potato is more likely to remain in its place, and not to be disturbed by the horse's foot.

The best plowman must be employed to trace the furrow in which the potatoes are set; first, to ensure that the furrow may be of a proper and uniform depth, three inches on a heavy, and four or five on a sandy soil; secondly, to enable him to correct any errors which the others may have made in the width of their furrows. This first plowman always traces the first furrow in commencing a new bed. The width of the beds must be measured at the two extremities, and poles set up there, in order to preserve as much as possible the parallelism of the beds.

If the laborers are well practiced, three plows and five planters will finish eight acres per day, or six at the least. Each planter must have his sack of potatoes within his reach.

A week after the setting, the ground is harrowed, an operation by which a few weeds are destroyed. Great numbers of them afterward spring up. Nothing more is, however, done to get rid of them till the potatoes are about to spring up, and some of them just beginning to show their leaves above ground. The extirpator is then passed lightly over the whole surface of the field.— This may be done without fear of hurting the potatoes. The whole of the weeds are thus de-

stroyed. The soil is left in this state till all the potatoes have come up, and is then harrowed to level it. After this harrowing the potatoes are as clean as if they had been carefully weeded, so that it only remains to pass the scarifier or horse-rake over them.

No injury will result from the plants not having been originally set in rows in all directions, for the first cultivation with the horse-hoe will place them so. It seems, indeed, as if they were benefited by a little compression on one side.

The first cultivation is performed with the small hoe, and should be given in the direction followed by the marking plow or furrower; the second must be performed with the horse-hoe, and in the direction of the plow. This will be sufficient in the greater number of cases. The haulm will then recover itself, and shade the whole field. If a few weeds should have escaped here and there by growing close to the potatoes, it will cost but little labor to pull them up while yet in flower.

If a third cultivation be thought necessary, it is performed in the same direction as the last. It would be difficult to recut the sides and edges formed by this last cultivation, especially if the potatoes be somewhat advanced in their growth.

By these operations, the cultivation of the potatoes is completely finished before harvest time; and nothing remains to be done to them till they are ready for taking up.

When the soil is tenacious and exposed to humidity, I prefer the following method of cultivation:—

The soil having been well prepared, lines crossing transversely are traced with the marking-plow, and a potato set at each intersection. The planting goes on much more quickly in this way: one man can easily plant three acres per day. The small horse-hoe is then passed close to each row, and covers it completely with earth. When weeds spring up, they are destroyed by passing the large horse-hoe in the same direction, an operation which is performed whether the potatoes have come up or not. When the potatoes have grown up to a certain hight, the banks or edges formed hy the hoe in the last cultivation are cut transversely with the large hoe. Another and final cultivation is perhaps given in the direction of the first.

The advantages presented by this method when applied to an argillaceous soil, are very striking. The potato is surrounded on all sides by light earth, and dung heaped round it. It is completely preserved from any excess of moisture that might injure the crop, because it is placed above the bottom of the furrow, by which the water drains off. The soil in which it rests is also thoroughly warmed by the sun

But the use of the extirpator, by which so much good is effected, is entirely precluded by this method; neither can the paring-plow be used. The difficulty of keeping weeds under is thereby increased; and it therefore becomes of great importance to perform the cultivation at the exact time when the soil is in the proper condition, otherwise we shall be reduced to the necessity of weeding and cultivating with the hand-hoe. This method is, however, by no means proper for dry and sandy soils; for it would cause the plants to suffer in dry weather. And, lastly, a sharpish frost attacking the potatoes before they were gathered, might penetrate too deeply into the ridges. I therefore recommend this method for those soils only in which potatoes might suffer from excess of moisture.

As to the other methods in use, I refer to my observations on them in the first and third volumes of my "English Agriculture." For my own part, I confine myself to the two methods just described.

When the earth has been laid up for the last time, and the potatoes begin to blossom, they must be left quiet; for it is then that the young tubers are formed. Some persons have recommended that the flowers be cut off, in order to increase the growth of the tubers; but the recommendation is absurd. Cullen, of Edinburgh, observed some time ago that the development of the tubers keeps pace with that of the flowers; and experiments specially directed to this point have uniformly shown that the crop is much injured by the removal of the flowers.

Cullen also tried the effect of cutting off the leaves as fast as they grew; the consequence was that the potatoes produced no tubers, but merely filamentous roots. The experiments of Anderson, showing the injury occasioned to potatoes by the hasty removal of their leaves, are recorded in the first volume of my "English Agriculture," p. 403.

The digging the crop has always been looked upon by great cultivators as the most difficult part of this branch of husbandry, and has been the main cause of their unwillingness to undertake it on the large scale. Since the year 1798, however, when I first took upon myself to recommend the cultivation of potatoes, this fear has greatly diminished; it has, indeed, been found that the getting in may be performed with greater facility and expedition than was formerly thought possible. It takes place at a favorable time, when the women and children have nothing else to do, and the weather is commonly fine. It is a labor which they willingly undertake, being encouraged in it by the idea that they are earning their subsistence for the winter. For my part, I know no method more appropriate than that of paying them with part of the produce: if the potatoes are planted according to my method, they do it cheerfully for a twelfth of the produce; sometimes, when my potatoes have been very successful and those of other persons are not particularly fine, even for the fifteenth. If they get more than they can either consume or preserve, the surplus is purchased of them at a fixed price. The work goes on very quickly: those who perform it employ their children to help them; whereas, if executed by day labor it would be very tedious.

Potatoes are taken up by means of a vine-dresser's mattock, which has two points, after they have been cut and stripped of their haulm. When they are planted according to my method, one man can with such an instrument easily prepare work for twelve pickers. In this manner potatoes may be taken up at less cost than with the plow. The latter method is, moreover, attended with various inconveniences, especially that of not enabling us to determine beforehand the quantity that will be raised in a day; in consequence of which a portion may be left unhoused at night, and injured by frost. The mattock just spoken of takes up all the tubers so completely, that I

have never thought it worth while to go over the field a second time for the purpose of collecting any which might have been left behind.

It is very extravagant to use sacks in gathering potatoes; they never last more than a year. I make use of boxes which hold about thirty bushels, and are placed on wagons. In one side of these boxes is an opening, which shuts by means of a sliding door. When the boxes arrive at the barn, the door is opened, and a kind of gutter adapted to the opening, and along this gutter the potatoes descend to the place intended for them. These boxes are likewise useful for other purposes.

Potatoes dug in dry weather may with safety be placed immediately in a cellar, or store-house protected from frost; but the place in which they are kept must be left open, to afford a free circulation of air, till cold weather comes on. But if the potatoes are raised in damp weather, it is better to spread them out on a floor, and let them dry there.

Cellars or houses protected from frost by double walls, are certainly the best places in which potatoes can be kept. These vegetables may, however, be perfectly well preserved in heaps, covered with straw: when packed in this way they are quite out of the reach of danger from frost, and keep better than in pits. Heaps of potatoes may be formed containing 20 winspels (480 scheffels) and more; but it is better to proportion their size to the room which can be given to them in the buildings, so that an entire heap may, when wanted, be carried thither at once; a day on which there is no frost being chosen for the purpose.

It is best to give these heaps an elongated form, like a roof, especially when they are large; but a point of greater importance is to cover them all over with a layer of straw, at least six inches thick. This layer of straw should be thickest near the ground: it should there extend beyond the heap of potatoes, so as completely to prevent the access of frost. The straw should be well trimmed at the summit and angles, and the whole covered up with earth. It is not, indeed, the earth which protects the potatoes from frost: this effect is produced by the straw, which prevents the radiation of heat from them; but the earth should be closely pressed to prevent the air getting through the straw. Earth which has no consistence and easily crumbles is, therefore, unfit for the purpose; if no other can be obtained, some kind of covering must be placed over it. For this purpose we may use the haulm of the potatoes, taking care to protect it from wind by means of the hurdles used for penning sheep, or in any other convenient way. If plastic earth can be obtained, these precautions will not be required: it will then be sufficient to spread the earth equally over the whole surface; beat it carefully, in order to make it even and solid; and examine it now and then to see whether any holes have been made by the mice, by which frost may gain access to the heap.

A precaution very necessary to be observed, is not to close the heaps completely in autumn so long as the weather continues warm. A small quantity of air must be allowed access through the top till frost comes on; a vent will thus be afforded for vapors which rise from the heap. An aperture is then left in the straw at the top of the heap, and frequently examined in order to discover whether any odor, indicative of fermentation, is given off: should such be the case, a greater quantity of air must be immediately admitted. It is only when continued frosts come on that the covering must be completely closed.

Potatoes remained uninjured in heaps of this description during the winter of 1802–3, when the frost penetrated the soil to the depth of three feet, and injured all potatoes kept in pits which were not well protected on all sides with straw, and many that were kept in cellars. Covering the heaps with dung is always useless, and often mischievous.

When a thaw comes on, it is prudent to open the heaps a little at the top, to permit the escape of vapor.

It would be superfluous to add any observations on the use of the potato. Let us merely pause for a moment on the value which it bears in proportion to that of other plants, according to its nature and the quantity of nutritive matter contained in it.

To compare potatoes with rye. Good potatoes contain by weight 24 per cent. of nutritive matter, and rye 70. If a scheffel of rye weighs 82 lbs. and a scheffel of potatoes 100 lbs. 64¼ scheffels of potatoes will be equivalent to 24 of rye.* Consequently, 2 scheffels 12 metzen of potatoes will be nearly equivalent to 1 scheffel of rye. But this estimate supposes that the tubers are good, solid, full of starch, and grown upon dry land, as was the case with those which Einhof selected for analysis. For, as later analyses have shown, the difference between the several varieties of the potato is much greater than Einhof then admitted, since the inferior varieties cannot be admitted to contain more than 20 per cent. of nutritive matter; and, consequently, 3 scheffels of them will be required to give the same result as 1 scheffel of rye.

The results obtained in brandy distilleries where the potatoes are not of the best quality, corroborate the assertions just made. According to the most skillful practical distillers, 3¼ scheffels of potatoes do not yield more brandy than 1 scheffel of rye; but that obtained from potatoes is the stronger of the two.

It is universally admitted, that for feeding cattle 2 scheffels of potatoes are equivalent to more than a quintal of hay, and that 1 scheffel of these tubers is worth at least half a quintal of hay; it must be understood, however, that part of the food given to the cattle must consist of hay or straw, in order to facilitate digestion.

In establishments in my neighborhood in which cattle are fattened in large numbers, it is perfectly agreed that an ox fed with half a scheffel, or 50 lbs. of potatoes, and 5 lbs. of hay per day, fattens as quickly as if he consumed 33 lbs. of hay; and cattle-dealers prefer putting oxen on this potato-food, to giving them hay alone. Theoretically, we are unable to decide on the value of potatoes in comparison with hay, as positively as we can on their value relatively to grain, because their constitution is very similar to that of grain, and very different from that of hay. We must, therefore, appeal to experience for information on this matter.

* Vide "Einhof on den Annalen des Ackerbaues." Bd. iii. S. 356, and Bd. iv. S. 627. A.

In England, endless disputes have been raised about the utility of potatoes in comparison with turnips, for feeding cattle. As a result of this controversy, the great cattle-feeder, Campbell, declares most positively that he cannot get, out of his own estate, 1 bushel of potatoes for 2 lbs. of beef, independently even of the dung which they would afford. Now, a bushel is equal to 0·645, or nearly ⅔ scheffel. Consequently, for the nourishment of cattle, a scheffel of potatoes is equivaleot to 3 lbs. of beef (free of expense).

We shall, hereafter, speak of the use of potatoes for feeding milch cows, a mode of application on which the results of different trials are very discordant: and also of their use for feeding sheep.

As potatoes rarely constitute an object of wholesale trade, it is important to form an exact estimate of relative value for consumption, and of the price which they return to the cultivator who raises them for his own use—a price which must not be confounded with that of the markets.

According to the produce which I formerly obtained from land of average quality, well and deeply cultivated, and strongly manured, I was in the habit of considering 140 scheffels per acre of Calenberg (which exceeds that of Magdeburgh by about 4 perches) as an average produce: but in this part of the country I have not yet obtained the same amount. The largest produce that I have here obtained is 120 scheffels per Magdeburgh acre: this was in 1809. In 1810, which was a year of scarcity, I obtained but 78 scheffels; the usual amount has been between 80 and 90 scheffels. I therefore take 80 scheffels per acre above the sets, as the basis of my calculations; the quantity which I usually employ for sets amounts to 5 or 6 scheffels per acre.

Taking very moderate data, such as may always be realized, for basis of the calculation, the labor of cultivating potatoes may be estimated as follows, for 50 acres:—

	DAYS' LABOR.			
	Of a Horse.	Of an Ox for relay	Of a Man.	Of a Woman.
Deep plowing in autumn, at the rate of ¾ acre per day's work of the plow		66⅔	33⅓	
Light harrowing, a team, 16 acres	12½		3⅛	
Carrying 400 wagon-loads of dung; 10 loads per day by team, requiring 160 horses and 40 men, of which one-third is to be charged to the potatoes	53⅓		13⅓	
Loading and spreading by team, one man and one woman; one-third charged to the potatoes			13⅓	13⅓
Burying dung, 2½ acres per day		40	20	
Harrowing 10 acres by team	20		5	
This preparatory labor amounts, according to the valuations subsequently given, to the sum of 47 rix-dollars 37 gros. 2 den.; or 23 gros. per acre.				
Passing the mark-plow twice crosswise, 10 acres per day	5		10	
Putting tubers in the ground, with 3 plows and 5 women, 6 acres per day		50	25	41⅔
One porter and superintendent			81⅓	
Light harrowing, 16 acres per day by team	12½		3⅛	
Passing the extirpator by team, 12 acres per day	16⅔		8⅓	
Giving the first cultivation with the horse-hoe, and one horse, five acres per day	10		20	
Giving second cultivation with the large hoe and two horses	20		20	
Pulling up weeds which may have escaped the cultivations				25
Taking the crop, if performed by day labor, 1 man and 8 women per acre			50	400
Carting by team, 3 acres, or 12 winspels	66⅔		16⅔	
One laborer, to aid in housing			16⅔	
Total	216⅔	156⅔	266¼	480

According to our average proportions, if a scheffel of rye be worth one rix-dollar, we must reckon—

A day's labor of a horse at ....5 groschen	A day's labor of a man ....4 groschen.
" an ox for relay ....3 "	" a woman ....3 "

Hence 216⅔	days' labor of a horse	1083⅓	groschen.
156⅔	" an ox	470	"
266¼	" a man	1065	"
480	" a woman	1440	"
50 acres cost, therefore		4058⅓	groschen.

consequently one acre costs three rix-dollars, nine groschen and two deniers.

If the crop amount to eighty-one scheffels over and above the sets per acre, each scheffel will cost one groschen.

Every one must, however, make his own calculation according to the particular circumstances of his locality.*

Let us now inquire at what amount the ground-rent and price of manure must be estimated.

If the land require from time to time a complete summer fallow, and if it be also necessary in the

* This is so far true, that on my property at Genthod, on the borders of the lake of Geneva, the average cost of a horse's day's labor in the interval between the 1st of March and the 1st of November amounts to 3 francs, independently of the driver. In my Italian estates it is the same. During winter, I reckon these days' labor at one-fourth less, because they are then less useful. The average price of a man's day's labor in summer is, at Genthod, 2 francs: and on my Italian estates, 1 franc 50 cents: that of a woman, about half.—1815. *French Trans.* These averages have, since that time, considerably diminished, at least on my Italian estates.—1829. [*French Trans.*

course of cultivation of potatoes, or any other weeded crop, to give a dead fallow, the potatoes must certainly not be charged with rent; they ought rather to claim a bonus, inasmuch as they save or rather effect the costly operation of this fallowing.

The dung and nutritive matters absorbed by potatoes must undoubtedly be laid to their account, if they are to be sold off the establishment; but if they are intended for home consumption, they scarcely absorb as much as they afterward afford in the shape of manure. The least result given by experiments on the quantity of manure produced by potatoes shows that 100 lbs. of these vegetables given as food to the cattle yield 66 lbs. of dung; consequently, 80 scheffels of potatoes will yield 5,280 lbs. of dung: but 800 lbs. of the straw of these plants will also produce 1,840 lbs. of dung; therefore, the quantity of potatoes grown on an acre of ground will yield three good wagon-loads of dung, that is to say, at least as much as they consume. But how far superior is this dung to that produced by the ordinary nourishment on dry fodder! This fact is well known to every one, and has been very judiciously noted by Kähler. (Vide *Annalen des Ackerbaues*, bd. xii. s. 228.) We cannot, then, charge potatoes with the consumption of any quantity of manure, for they really furnish a large additional supply of that material, inasmuch as the animal life which they support constitutes a new and active element for its formation.

But land is often let to poor people for growing potatoes. If the land thus disposed of has been properly prepared and dunged, the produce of each perch of 12 feet square (or 144 square feet of surface) will be worth 1 groschen, making that of an acre worth 11 rix-dollars 6 groschen. From this we must deduct the cost of preparatory labors, which has been already estimated at 23 groschen; the remainder is therefore 10 rix-dollars 7 groschen.

If now we add this net profit in money to the cost of the potatoes cultivated for our own use, as a balance for rent and price of dung, the total cost will amount to 10 r.-d. 7 gr. + 3 r.-d. 9 gr. 2 den. = 13 r.-d. 16 gr 2 den.; consequently, 1 scheffel of potatoes costs 4 1-10 groschen. Such, then, would be the price of the potatoes; it might be increased to 5 gr. to ensure a fair profit; potatoes have never been sold at a price lower than this. But the nutriment consumed by the potatoes is lost by this system; and if 80 scheffels grown on an acre yield 16 r.-d. 16 gr., which, after deducting 3 r.-d. 9 gr. for expenses of cultivation, leave 10 r.-d. 7 gr. net profit, it remains to be seen whether, according to the circumstances of the rural establishment, this profit is a sufficient indemnity for the quantity of manure consumed.

But if the potatoes be consumed at home, the cost of their production cannot exceed 1 gr. per scheffel, or, making the fullest allowance for casualties, 1 gr. 4 den. But potatoes used for feeding cattle fetch 6 gr., when a pound of meat is sold for 2 gr.

For information respecting the remarkable separation of the fecula of the potato by the action of frost, by means of which the essential part of these vegetables may be preserved for a long time, and exported more easily than the seed, I refer to the *Annalen des Ackerbaues*, bd. iii. s. 389, and bd. xi. s. 1. This property of the potato has not hitherto been turned to much account.

The Field-Beet.

This plant, also called *mangold-wurzel*, and sometimes *root of scarcity*, (*mangel-wurzel*) is, with all its varieties, either a descendant of the *beta vulgaris* alone, or the result of the mixture of this plant with the *beta cacla*. I regard the difference pointed out by botanists between these two plants as too insignificant, and, as far as my observations go, too vague to serve as the foundation of an absolute distinction. It appears to me that the crossing of the deep-red colored garden-beet and the white beet has given rise to all the existing varieties of this plant, some approaching to the former, and others to the latter species; and that from these again new varieties are continually produced, among which we now and then meet with individuals belonging to one or other of the original species. It is, therefore, impossible to distinguish precisely between the various kinds of beet any more than between the several kinds of other cultivated plants, the varieties of which pass one into the other by insensible gradations.

The two kinds of beet which occupy the extremities of the series are the deep-red beet which has long been cultivated in our kitchen gardens, and that which is perfectly white. Between these there are the large scarlet beet; the flesh-colored beet, which is sometimes marked with rings of that color; the variety which is red without and perfectly white within; the yellow beet; and that whose color is a mixture of yellow and white. The color of the root commonly resembles that of the leaves or rather of their edges, which are either quite green* or tinged with red.—Even seed taken exclusively from one plant always produces several different varieties. The unmixed red and white are, however, the most constant.

The pale-red beet is the largest and most productive of all, and is, therefore, usually cultivated as food for cattle. There are two varieties of this; one whose root buries itself under ground, and another which shows a disposition to rise above the surface. My own observations lead me to consider these dispositions as essentially belonging to the varieties in question; but the nature of the soil has also considerable influence upon them. I once divided with a friend a quantity of seed which had been given to me as belonging to the variety which rises above ground; my plants plunged deeply into the soil, while those of my friend grew chiefly above the surface. My land was plowed to the depth of ten inches, and his to a small depth only.

On a soil of small depth, the variety which grows above ground is certainly to be preferred, as on such a soil it produces a heavier crop than the other; but on a deep soil the underground variety is preferable, if only from being less exposed to injury from frost in autumn.

The yellow and white beets, on the other hand, have the advantage of possessing greater consistence, and resisting cold rather better; but chiefly because they contain a larger quantity of sugar—a fact which is asserted by all those who have made experiments on the manufacture of sugar from beet-root; they are, therefore, commonly preferred for the manufacture of sugar and syrup,

* Rather whitish. [*French Trans.*

perhaps also for the distillation of brandy. But for agricultural purposes, these qualities do not compensate the greater volume obtained from the reddish varieties.

Beet grows on all soils which contain a moderate quantity of moisture, and a large proportion of nutritive matter; but on sandy soils its size is small, unless, indeed, a large quantity of rain fall during the period of its growth. On a light soil, rich in humus and moist by situation, it becomes watery and very thick, but hollow in the middle, and difficult to preserve from rafting quickly.— The soil best adapted for beet is an argillaceous soil possessing moderate tenacity; on land of this description it always succeeds, and acquires more consistence than on any other kind of soil. I therefore make it a rule, in the cultivation of weeded crops, to sow the greatest quantity of beet on tenacious soils, and of Swedish turnips on those which are sandy.

To produce beet of large size, the soil must be well manured; but it matters not whether the manuring has been performed expressly for the beet or for a preceding crop, provided that, in the latter case, the soil still remain in good condition. Fresh manure should be mixed with the vegetable soil by two plowings at the least.

The deeper the soil the better is it adapted for the growth of beet; to obtain a good crop of this vegetable on a soil of small depth, it is better to sow or plant it on beds or ridges.

The seed may be then sown on the spot where the plant is to grow. The individual grains may be placed in separate holes, or the seed may be drilled at least twice as thickly as the plants are to remain; but this latter method is practicable only on a warm, light soil, which is tolerably free from weeds; for the germ has some difficulty in opening the hard skin in which it is enclosed. It is a considerable time before the young plants display their seminal roots, and by that time the field is covered with weeds of considerable hight. The germination is often interrupted, either because the seed is too near to the surface, and cannot find a proper supply of moisture, or because it is too deep in the ground, and development becomes impossible. The only way of getting rid of weeds is to mark the lines on which the seed has been sown, in order to destroy them with the horse-rake before the beet-plants come up; this, however, requires extraordinary attention. Beet has also been sown broadcast, and, subsequently, thinned by weeding and hoe cultivation; so that the plants are ultimately isolated: but this method is the most troublesome and expensive of all.

On ordinary soils, transplantation is usually the preferable plan, as it leaves time for giving the requisite preparation to the soil. But as the vegetation of the plant is disturbed by transplantation, it is important to procure the seedlings in good time, and, therefore, to sow as early as possible, in a very warm situation, and on a light garden soil. The seed may also be committed to the ground at the end of autumn; it will then remain dormant during the cold season, but the husk will become somewhat softened. But the trifling advance in point of time which this method affords, does not compensate for the danger to which the seed is exposed while in the ground, from the attacks of mice and insects: this circumstance has caused the plan to be almost universally abandoned.*

The plants require careful cultivation during their growth; it is upon this indeed that their success mainly depends. The cultivation is performed with the horse-hoe; but, in spite of the opinion of some agriculturists, a slight earthing up is very useful, even to the variety which grows chiefly above ground. The large fleshy leaves of the plant attain their greatest size in August; many cultivators set great value on the green fodder furnished by these leaves. According to approximate calculations, if the leaves be stripped early and frequently, the produce which they afford is greater than that of the roots; but it is obtained at the expense of the latter: for, if the leaves be stripped early and to excess, the roots remain very poor. Cattle eat these leaves, but are not very fond of them; and, though large, they appear to contain but a small quantity of nutriment. Whatever is gained in real value on the leaves, is lost upon the roots: moreover, the gathering of the leaves is troublesome; and, on the whole, I think that nothing but a scarcity of other kinds of fodder can justify this operation in an economical point of view. It is only in autumn, when the plants have attained their full growth, and the crop is soon to be taken off, that the leaves can be properly cut close to the root, and given to the cattle.

The roots are easily pulled up; but the removal of the filaments which is necessary to the preservation of the roots, is not so easy. Beet-roots grown in an argillaceous soil have not so many of these filaments.

It is difficult to preserve the roots to an advanced period of the winter, for they are very sensible of cold, and soon destroyed by it. In warm cellars they are very liable to rot, so that they require to be placed in beds, and separated by straw or sand. The best mode of keeping them is to place them in heaps of moderate size, and cover them with straw, in the same manner as potatoes are kept.

My own experience has shown me that the produce of beet may amount to 300 quintals per acre; this, however, is an extraordinary quantity: even on a soil especially adapted to the plant, we cannot reckon on an average crop of more than 180 quintals per acre. In the duchy of Magdeburgh, it is calculated that a square foot of land will produce a pound of beet-root: this would make 235 quintals per acre. But from this we must deduct one-fourth for accidents which may injure the crop. The quantity of nutriment contained in beet cannot be estimated at more than 10 per cent.; compared with that contained in hay, it is as 10 to 46; with that of potatoes, as 28 to 46.†

* The method which is found to be most advantageous on my estates, consists in advancing the germination a few days before sowing, by moistening the seed with water from the dunghill, and then setting it in rows, two or three grains at a time, along a cord on which equal distances are marked. The seed is placed in little holes, about an inch or an inch and a half in depth, and formed with a dibbler: it is covered with mould taken from the preceding hollow; or, if the soil be very light, the earth is pushed over the seed by the foot of the sower as he advances. When this plan is pursued, germination takes place quickly, and the weeds do not get the start of the beet-plants. Care must be taken to uproot the superfluous plants as soon as those which are to remain have put forth three or four leaves. [*French Trans.*

† I am inclined to think that either the northern climate, or the soil of our learned author's estates, imparts to the beet-root properties different from those which distinguish ours. With regard to the leaves, our opinions are in accordance; but as to the root, I am disposed, from the result of various experiments, to be-

The large proportion of sugar which beet-root contains renders it particularly agreeable and beneficial to cattle. When given to cows it contributes greatly to the formation of milk, to which it imparts an agreeable flavor; and, when mixed with potatoes, it appears to improve the milk in an extraordinary degree.

Beet possesses the advantage of being almost exempt from the attacks of insects.

As the culture of beet for the manufacture of sugar has lately excited particular attention, I shall here add a few observations on that subject.

The best variety of beet for this purpose is the perfectly white; next to that, the yellow: the reddish variety is inferior to all others. The former have been found to be richer in saccharine matter, but their produce is much less than that of the latter. Although, therefore, in the former the separation of the sugar is easier, the rough produce which they yield is less in quantity, so that the cultivator cannot obtain them at the same price. Moreover, beet-root raised for the extraction of sugar should not be grown on a very rich and strongly manured soil, for it will then contain a great deal of saltpetre, and but little sugar. Finally, it is said that the roots must be preserved from the influence of light; they must, therefore, be covered up with earth. The variety least adapted for this purpose is that which grows chiefly above ground. The beet-plants must be placed as close together as possible, which greatly increases the expense of cultivation, and diminishes the produce. Lastly, they must not be stripped of their leaves before gathering, but allowed to grow covered with their leaves, which appears a great sacrifice to some cultivators.

According to calculations made upon large quantities of these roots, it appears that to render the manufacture of sugar profitable, the quintal must not cost more than 6 groschen. The cultivation of beet may be advantageous even at this price in localities where manure can be procured from without, even though a wagon-load of dung should cost 2 rix-dollars. Where this facility is unattainable, the culture of beet in large quantities is attended with difficulties, because it certainly consumes a portion of the nutritive matter contained in the soil, and, if sold, yields little or no manure. When a cultivator can realize 3 groschen per quintal for his beet, by using it to feed his own live stock, he ought certainly to prefer this mode of employing his crop, in order not to diminish his supply of manure. Hence there will always be considerable difficulty in keeping large factories constantly supplied with a proper quantity of this raw material. The great question respecting the advantage of extracting sugar from beet-root cannot remain long undecided, now that establishments for the purpose have been erected in so many countries. The possibility of this mode of preparation is beyond all doubt.

The Turnip (Brassica rapa).

Various kinds of turnips are cultivated: and, according to the nature of the soil and the culture bestowed upon them, perhaps also by the mixture of their pollen with that of other species, new varieties are produced almost without number. It is probably by cultivation that the varieties to which we give the preference for field culture have acquired their present form and size, and that these properties are transmitted by seed from one generation to another, provided no degeneracy is occasioned by neglect of culture.

In a botanical point of view, some turnips appear to spring from the *Brassica rapa*, others from the *Brassica oleracea*, or perhaps from crossing, to which the Brassica family seem very much inclined.

In an economical point of view, turnips are chiefly distinguished into two classes, viz., those which require to be sown where they are to grow, and will not bear transplanting (at least not without a large ball of earth adhering to them), and those which are usually transplanted, or will at least bear such treatment.

Turnips which will not bear transplanting—Turnips properly so called.

Turnips of this class are derived from the *Brassica rapa*, and are much more watery than those which will not bear transplanting. They exhibit endless diversities of form and color. They have an enlargement in the root, which in some is large, round, more or less compact, and is shaped like an onion with a tap-root at its lower part: others have rather a fusiform root, terminating in a point at its lower extremity, and changing by degrees into a tap-root. Both varieties are sometimes white, sometimes inclining to yellow, sometimes tinged with red or green. Sometimes they stand with the greater part of their bulk above ground, sometimes below. Their size is infinitely diversified, and appears to depend chiefly on cultivation. But the disposition to attain a large size is transmitted by seed through several generations. The turnips which in England sometimes attain the weight of 60 or 70 lbs., appear to be absolutely identical with those which in our country usually weigh about ½lb.; indeed, I have already increased the weight of some of the latter to 14 lbs. Large turnips are not indeed a particular variety; but it is, nevertheless, important to preserve their seed, when we intend to cultivate these plants.

In Germany we have long been familiar with the difference between turnips sown on the fallow-field and those which are sown on stubble-land; the former are known to grow to a much greater size. But we do not here pay the same attention to turnips sown on the fallow that they do in England, where these turnips form the principal source of food for their live stock, and are the corner stone of thir system of husbandry. In England, too, turnips are the crop usually selected to supply the place of fallowing; and the system now known by the name of alternate cultivation is

lieve that it contributes as much, and even more, to fatten animals, than to increase their milk: it is true, however, that the roots impart an agreeable flavor to the milk, according to an experiment made upon sheep during the winter of 1809-10, to which I paid close attention for more than a month. I believe 252 lbs. of beet-root to be equivalent to 100 lbs. of natural hay.—1815. *French Trans.* This proportion has been confirmed in my establishment, not only by a second direct experiment very carefully conducted, but likewise by all the results of my rural economy, in which, as is well-known, everything is submitted to the most rigorous computation; and to that which is the basis of all computation, viz., weight and measure.—1829. [*French Trans.*

also designated as *turnip cultivation*, and sometimes as the *Norfolk and Suffolk system*. For information on this system, I refer my readers to the 1st and 3d volumes of my "English Agriculture," supposing that all who wish to adopt this mode of culture will have that work in their hands. I have nothing to add to what I have there said, excepting that the annoyance of plant lice and caterpillars has given me a great dislike to the system.

In Germany turnips are sown on the fallow at the end of June or the beginning of July, after the land has been plowed three times and manured.

Cultivators who are able to pull up the weeds usually do so; but rarely hoe or thin the turnips, or regulate the spaces between them. When the crop succeeds, the produce is considerable, though rarely equal to that of the English hoed turnips; if it fail, the loss of the seed is disregarded. But as the culture of other plants on the fallow is more productive, we rarely sow turnips on it.

In Germany turnips are more generally raised on stubble-land. This cultivation is indeed very common in the western parts: on the banks of the Rhine it has been in use from the earliest times; but it is decreasing, and, indeed, almost disappearing in the countries north of the Elbe. This decrease cannot be attributed to the influence of climate; the crop is not usually later in these parts than in the west, neither does winter come on earlier. This culture is, however, highly advantageous, and in the countries above-mentioned constitutes one of the chief foundations of the system of Agriculture. Why, then, has it been renounced in our part of the country? Chiefly because in large rural establishments there is such a press of business during harvest time, that it is difficult to break up the stubble after the first rye crops have been carried, which is an essential condition of this method of culture. In our large establishments the rent of land is usually of less amount than the cost of labor; and as turnips sown after harvest require cultivation, we prefer sowing them on the fallow, where their success is less precarious, and their cultivation takes place at a more convenient season. As to our smaller farmers, they are usually too poor to undertake this labor; and, moreover, they are without examples of this cultivation, which is, nevertheless, better suited to them than to establishments of larger extent.

Turnips require a sandy soil mixed with clay, rich, and neither very dry nor exposed to excess of moisture. For turnips sown after harvest (and it is of these alone that I am now speaking), the stubble is plowed superficially as soon as the rye is cut; this labor is often not deferred till the corn is housed, but the plow is passed between the stooks of grain. A strong harrowing is then given, and the stubble thus uprooted is collected with the rake and burned. When manure is to be had, it is put upon the land; this, indeed, is indispensable, if the soil has not been previously manured for the rye crop. Soon afterward the plow is again used, more deeply; then the ground is harrowed, and the seed sown as regularly as possible, the quantity used being about 1 lb. or 1½ lb. per acre; finally, the soil is once more harrowed, and then rolled. The turnips are sometimes sown after the first plowing, especially when the soil is very sandy; but they do not succeed so well as those which have received more efficient preparation. The sowing must be performed as early as possible, that the soil may not have time to dry.

When the turnips have put forth their leaves and taken root firmly, they are well harrowed. No notice is taken of the uprooting of a very few weakly plants by this operation; the loss of these is, indeed, favorable to the growth of the rest. Wherever harrowing is adopted, it is regarded as indispensable to the production of a good crop. Those who cultivate but a small extent of ground, and take great pains with it, have the larger weeds pulled up.

The success of the crop is altogether dependent on a fall of rain soon after sowing. When the latter part of the summer is dry, the sowing turns out a complete failure, the young plants being destroyed by aphides. The loss of the seed is, however, of no consequence, and the labor bestowed on the soil is beneficial to the following crop. Caterpillars are less dangerous to late than to early-sown turnips; they may be destroyed by means of the harrow and roller.

When the turnips are too thick, the smaller ones are pulled up about Michaelmas, and may, together with their leaves, be profitably given to cattle. The larger ones are left in the ground till November; they are then gathered, and the necessary quantity of them is given to the live stock, the leaves not being cut off; the remainder are stripped of their leaves, and stored up in cellars, or in heaps covered with straw.

If it be impossible to house the whole crop, part of it is left in the ground; the larger turnips only being taken up. With us, they are most commonly left in the ground during winter; and in spring, with their young shoots, they afford excellent feed for sheep. Sometimes also they are fed off by sheep on the ground, especially when they have not attained a very great size, or the requisite amount of labor cannot be bestowed upon them. But in winters, during which there is a rapid alternation of frost and thaw, turnips are sure to perish in the ground: hence, it is always desirable to house as many of them as possible.

It is not uncommon to obtain a crop of 20 or 25 quintals per acre. On land which has been manured expressly for the crop I have known the quantity to amount to 40 quintals.

Sometimes, when turnips have been gathered in December, autumn rye is sown upon the land; but the soil is more commonly devoted to spring grain, for the growth of which it is well prepared.

The nourishment afforded to the soil by the turnips left in it, and their young leaves, is, perhaps, an equivalent for that consumed by the rest. It is said that this method does not impoverish the land.

Turnips are not very nutritious in proportion to their bulk; but they furnish agreeable and wholesome food for sheep and horned cattle. It has sometimes been thought that turnips have given an unpleasant flavor to the milk of animals fed upon them; but this must have arisen from a decayed state of the turnips themselves, or their leaves; otherwise the butter made with such milk has a flavor equal to that made from the milk of cows fed upon grass. Turnips seem to be adapted to increase the quantity of milk rather than of fat, though in England great numbers of cattle are fattened on them. It is reckoned that an ox should have per day a third of his weight of

turnips. For the feed of cows, I consider 100 lbs. of turnips equivalent to 22 lbs. of hay. The very large English turnips contain a smaller quantity of nutriment in the same weight.

There is a variety of this vegetable called the *stubble* turnip: it is closely allied to the common turnip both in its nature and mode of cultivation. It is sometimes sown on rye-stubble, but more frequently on the fallow. The smallness of these turnips renders them too costly to allow them to be used for feeding cattle; but they are in request as an agreeable dish, and fetch a high price. The cultivation of these turnips is very profitable to the small farmer, who cultivates them with the help of his family, and cleans them for sale; but they are proportionably disadvantageous to the large proprietor; it has not even been found advantageous to raise them for home consumption It is not true that these turnips require a peculiar kind of soil, to be met with in certain localities only; every clayey sand which is light, clean, and well stored with old nutritive matter, agrees with them perfectly well.

Turnip-seed should not be gathered from plants which have been in the ground all the winter, and flowered early in spring; at all events, this should not be done many times in succession; for the turnips will then become smaller and smaller, and ultimately quite insignificant in size; so that, like rape cultivated for the extraction of oil, they will soon acquire a mere cylindrical root. On the other hand, the disposition to produce large turnips is transmitted through the seed when, in addition to other favorable circumstances, it is collected from turnips of the largest size, which have been chosen for the purpose, preserved from cold in winter in pits or cellars, and replanted in spring. It has, however, been observed that turnips raised from such seed are peculiarly sensitive of frost; and in England, as this disposition is regarded with considerable apprehension, the seed is from time to time collected from turnips which have been sown late in the season, and passed the winter in the ground, after having been carefully hoed.

Attempts have also been made to sow turnips with late tares, the latter having been sown in drills and harrowed, and then cut in the green state. It is said that the turnips being thus cleared of weeds yield a good crop. This may have happened in one or two instances when the tares have been accidentally destroyed by an early frost; otherwise I should fear that tares cut while young would shoot up again too strongly to leave the necessary room for the turnips. Buckwheat would be better adapted than tares for this purpose.

Turnips admitting of Transplantation—Turnip-Cabbage.

This is a descendant of the *brassica oleracea;* botanists distinguish by the name of *napo brassica* that particular variety which forms its root under ground, and is usually cultivated on an extensive scale.

This variety itself is divided into several subvarieties: it might indeed be possible to produce varieties out of number, by selecting the seed of plants which exhibit peculiar characters. The several varieties are distinguished by their color, which in some is perfectly white, and in others yellowish. The color is, however, not always permanent; so that yellowish plants are often produced from seed taken from a white one, and *vice versa.* They differ also in substance: some are firm and compact; others soft and spongy. These latter qualities are more permanent; they continue the same even when the color changes. The several varieties are also distinguished by external appearance by their base and their stem, so that they may be recognized at a glance. These differences, however, scarcely admit of verbal explanation, for they exist not in kind but in degree.

The kind of turnip so much prized in England under the name of *Swedish turnip* or *ruta-baga*, and extensively cultivated in Germany, is also a variety of the same species; its character can be distinguished only by sight or taste.

Turnips of this description require a soil more argillaceous than that which is most congenial to turnips properly so called, viz., those which do not admit of transplantation. This is particularly the case with the heavier varieties, which are usually white. On a dry sandy soil, they remain small, and yield but a scanty produce. The more porous kinds thrive better on a sandy soil; but the one which accommodates itself best to such land is the Swedish turnip. The advantage of this plant mainly consists in its thriving on such a soil, and, moreover, attaining a considerable size; we must, however, observe in addition that it is sweeter and more agreeable to the taste than the other varieties. Otherwise, I do not think that it is so nutritious as the more compact and usually white variety, though the latter is too hard to be used for domestic purposes. For strong land, I should recommend the cultivation of this variety, but on light land, that of the ruta-baga, because it yields a larger produce.

Many gardeners have maintained that the ruta-baga is identical with the yellow turnip-cabbage, which has been so long known; but the former is distinguished by its taste, and in an economical point of view, chiefly by thriving on sandy soils, and resisting frost well; whereas the yellow turnip-cabbage is the most delicate of all plants of this kind.

The mode of cultivation is the same for all these varieties. When the soil is not already well stored with nutriment, it must be strongly manured, and the dung well mixed by two plowings at the least.

The seed is sown either on the spot where the plants are to attain their full growth, or in seed-beds, from which they are afterward to be removed to the place prepared for them: they bear transplanting very well.

In the former case the sowing takes place from the middle of May to the middle, or, if necessary, to the end of June. It is not advisable to sow earlier, for the plants will then be inclined to run to seed in autumn, and the roots to become woody.* If, however, transplanting be preferred, it is better to sow as early as April, for the plants are much retarded by transplantation. They thrive

* I know not how to designate in any other manner the state which the turnips assume when the formation of hollow cells takes place, and the diminution of fluid matter causes the fibres to become more closely packed. Our peasants denote this state by the epithet *coriace.* [*French Trans*

particularly well when sown or planted on ridges, but it is then somewhat more difficult to keep them clear of weeds. In other cases, they are cultivated with the horse-hoe, and afterward earthed up, but only to a slight extent; otherwise, the mould would cover their leaves. Toward the middle of September they may be stripped of their leaves, and will thus yield an abundant supply of fodder.

Turnips of this class, especially the ruta-bagas, are more capable than the others of resisting the effects of cold: the best mode of keeping them would be to leave them in the ground after it had been well drained, were it not that they show themselves above the surface, and are in consequence very liable, when left in the field, to be taken up by men or devoured by animals, both wild and domestic. When they are kept in store-houses, or in heaps, there is more fear of their becoming heated and putrefying, than of their being injured by frost. They are not easily destroyed by by cold: they still continue good after a thaw, though they are certainly more sensible to cold in this state than when left in the ground with all their roots; and to a certain extent, continuing to vegetate. When collected in pits or cellars, they are very likely to rot.

That portion of the crop which remains unconsumed at the beginning of the new year may be most advantageously deposited in barns or store-houses, arranged in layers separated by straw: there will then be no fear of injury from frost.

The produce of those varieties of the turnip which bear transplanting, and especially of the Swedish variety, is, when no accidents interfere with it, greater perhaps than that of any other vegetable of this description. I have myself gathered from land not perfectly manured, as much as 240 scheffels (full measure) per acre: the weight of this is about 24,000 lbs. exclusive of the leaves. But I have also met with frequent failures in the culture of these turnips, and have seen them injured by plant-lice, by the caterpillar which attacks the cabbage, and also by that which attacks rye. The last-mentioned insect is particularly fond of this plant; and, in 1810, in consequence of the drouth which took place at the end of the summer, it attacked all the plants of this description. The attacks of insects render the cultivation of these vegetables much more precarious than that of potatoes or beet.

According to the analyses of Einhof, the quantity of nutriment in the Swedish turnip is, to that of the common turnip, as 15 to 12, a result which is in accordance with those of experiments made on the fattening of cattle with these vegetables: compared with that of potatoes it is as 15 to 25

Plants of this class are eaten with avidity by cattle of all kinds, and have great influence on the secretion of milk. When not in a state of putrefaction, they do not impart an unpleasant flavor to the milk.

These considerations speak loudly in favor of the cultivation of the vegetables under consideration, provided, however, we do not place our whole reliance upon them; for it must be remembered that they are liable to accidents.

The turnip-cabbage, distinguished in botanical language by the name of *Brassica oleracea; var. gongylades*, also belongs to the same family. Several varieties of it are cultivated in gardens: it is better adapted for culinary purposes than to furnish food for live stock. Some persons recommend its cultivation as a field crop for this latter purpose, because it is easily gathered and cleaned during winter, its turnip being wholly formed above ground. I have seen a variety whose turnip was more cylindrical, some of the plants bearing small heads of cabbage. This must certainly have been a cross between the common cabbage and the turnip-cabbage.

With regard to cultivation, this plant does not differ from those already spoken of; but it requires a strong soil, well manured, and particularly well cultivated; the same kind of soil, in short, as that required for cabbages.

Common Red and White Cabbage (*Brassica oleracea;* var. *Capitata*).

There are several varieties of this plant: I do not here speak of those which are cultivated in gardens, but of the common smooth cabbage. This latter also exhibits considerable diversity in form, size, and color: it is either white, red, or tinged with a mixture of both colors: in shape it is sometimes flattened, sometimes tapering to a point: in the latter case it is called the *sugar-loaf cabbage*. There are some kinds of cabbage which, when cultivated on a proper soil and with due attention, will form heads weighing from 20 to 30 lbs.: it is said, indeed, that their weight sometimes amounts to 80 lbs. Other kinds, and particularly the sugar-loaf cabbage, seldom weigh more than 3 or 4 lbs.; though some heads may attain the weight of 6 or 7 lbs. Many persons look upon those kinds of cabbage which grow to a large size as highly advantageous, and are even at a loss to imagine why cultivators in general rest contented with the smaller kinds. But any one who is practically acquainted with the two varieties, and examines them with due consideration, will certainly give the preference to the smaller. The large cabbage not only requires a very rich soil, but a proper regulation of the interspaces, to the width of four feet in all directions for the very largest, and three feet for the next in size: consequently, only nine plants of the former, and sixteen of the latter can be grown on a square perch. The small variety, particularly the sugar-loaf cabbage, succeeds admirably in rows placed at intervals of two feet, the plants being set six inches apart in the rows; so that 54 plants grow on a square perch. It is almost sure to attain its full development, while the other often remains weak and sickly: it also becomes more compact, and is more easily preserved. As cabbage plants, even when treated with the greatest care and in a state of active vegetation, are liable to be destroyed by the larvæ of the cockchafer and the mole-cricket, there remains a large vacant space on the ground when a plant of the larger variety disappears from this cause; whereas, among those which are planted at small distances, the loss of an individual plant is scarcely noticed.

The cabbage requires a clayey soil in excellent condition, or well impregnated with humus, and in a damp situation. This argillaceous soil must be carefully and repeatedly mingled with warm and active manures; and, if possible, before the last plowing, sheep should be penned on it, or it should be watered with drainings from the stable. But even rich soils well supplied with humus,

require manuring before they are used for raising cabbages; the manure is, however, intended to act rather as a solvent than as a source of nourishment. In treating of the culture of hoed crops in general, we have said all that is necessary on the rearing and transplantation of the seedlings.—Cabbages may also be sown on the spot which they are to occupy during the whole time of their growth, the supernumerary plants being removed by hoeing: but this method is scarcely practicable excepting on very clean land. Great care must be taken to raise the seedlings in good time, so that the transplanting may be performed in May, during favorable weather.

Cabbages must be cultivated with the horse-hoe, and then earthed up at different times, until their leaves cover the whole surface of the ground. It is sometimes necessary to cultivate the soil quite close to the plants, and destroy weeds with the hand-hoe.

The cabbage may without injury be stripped of its leaves as soon as it begins to shed them, but not before. When this has been done, it is useful to earth it up again; new leaves will then be put forth.

The heads are plucked or cut toward the end of October; sometimes even later. If, however, in consequence of wet weather, they should begin to break, the gathering must take place earlier in the season. The stump is left standing together with the outer leaves, or the stem, which are afterward taken as they are wanted to feed the cattle. When there is a great abundance of these stumps, they may be consumed on the ground by the cattle.

There is perhaps no other plant whose produce is so great as that of the cabbage when grown on a soil adapted to its nature. Crops have been obtained of which the heads alone weighed more than 500 quintals per acre: 300 quintals per acre is by no means extraordinary. The cabbage is usually cultivated for sale, and may indeed be sold to great advantage by cultivators who possess land well suited to its growth, and situated in countries where it is not abundant. But the cabbage may also be advantageously cultivated solely as food for cattle, provided the soil be well adapted to it; notwithstanding that six quintals of cabbage are required to furnish as much nutriment as one quintal of hay, or two quintals of potatoes. When given in abundance, cabbages are well adapted for fattening cattle of all kinds, and produce large quantities of milk. If the rotten leaves be thrown away, milk and butter thus produced will have a pleasant grassy flavor.—Cabbages are considered very useful for ewes which have lambed.

According to the mean of my experiments, an ox which is being fattened consumes (per day) from 150 to 180 lbs. of cabbages; a sheep, 12 lbs.

But the cabbage is very difficult to preserve during winter. For even when, by exposure in the open field, it has been attacked by frost in all its parts, and is yet not spoiled when the thaw comes on, it nevertheless suffers considerable loss by the rotting of its outer leaves. It cannot be kept in cellars or warm places, for it soon rots there. The best mode is to leave it on its stem, to be taken when wanted; endeavoring, however, to have it consumed in the early part of the winter. Making it into *saur kraut* for cattle is a very good plan, but very tedious, and incapable of application on a large scale.

The cabbage is exposed to various accidents: to plant-lice in its infancy; to honey dew; after which it is again attacked by another species of plant-lice: to worms which attack its roots: and to caterpillars which attach themselves to its leaves and devour them, sometimes completely destroying the plant. These various enemies do not, however, wage war upon it to so great an extent in the open field as in gardens.

Carrots.

The culture of this plant for feeding cattle is practiced not only in England and Belgium, but also in various parts of Germany, and acknowledged to be very advantageous, provided the necessary care and labor can be bestowed upon it. The care required is, however, greater than that which is requisite for any other plant of this kind.

There are several varieties of the carrot, but they are distinguished from one another merely by size and color. The smaller kinds, usually sown in gardens or hot-beds for the sake of obtaining an early crop, are not looked upon as well adapted for the purposes of Agriculture; for which, on the contrary, those varieties are most in request which are disposed to grow very thick and long. Some carrots are of an orange color; others of a pale yellow: the largest that I have seen have been of the latter kind.

Carrots require a light, and therefore a sandy, soil; but it must be fertile to the depth of at least a foot. When this latter condition is fulfilled, carrots will thrive very well, even though the field should be cut off from all access of moisture.

A soil of this description requires no farther cultivation with the plow. If it has been once plowed to the depth of a foot, an operation which cannot be better performed than with a double-plow, it will be in a state of sufficient preparation. The soil must, however, be perfectly free from dogs'-grass, and all other weeds which multiply by their roots. If this be not the case, the weeds must be destroyed by two or three superficial plowings. It is for this reason that carrots are often cultivated after other weeded crops, by which the soil has been already cleaned. The deep plowing is given and the soil completely prepared in autumn, in order that it may sink down during winter, and the seed be sown as early as possible, even before the winter is over, and while the snow remains on the ground.

If the soil be still rich in nutritive matter, it will not require manuring; but if it be exhausted, the sparing of manure is a false economy, for it will occasion a considerable diminution of the crop, even though the labor of cultivation may be the same. After sowing, a quantity of dung, either very rotten, or else tenacious and full of straw, must be spread on the soil; when the carrots spring up, the residue of this dung must be removed with the rake. Many cultivators have found this method perfectly successful.

The sowing of carrots is attended with some difficulty, for the seed is much disposed to stick together. It must, therefore, be forcibly rubbed between the hands; otherwise it will fall in lumps.

But even after this trituration, the grains will sometimes remain adhering to one another: the best mode of proceeding in such a case is to mix them with wood-shavings, rub them well together, and then sow them. The quantity of seed is 3½ lbs. per acre; this will certainly be sufficient if it be well spread.

The cultivation of carrots is certainly much facilitated by drilling; but I have always found this operation difficult, on account of the disposition which the seed has to stick together. The young plants thus sown grow in tufts very close together, and the thinning of them occasions a great deal of trouble.

The seed must be but very slightly covered. In wet weather, it will penetrate the ground spontaneously: in dry weather, the soil is first harrowed, then the seed is sown, and lastly, the roller is passed over the surface.

The seed remains a long time in the ground before it springs up, especially when its germination is not favored by damp and warm weather; the young plants then grow up in a very weak state. In such a case the soil becomes covered with weeds before the plants make their appearance,* and the destruction of these weeds is absolutely necessary.

Some cultivators have succeeded in almost wholly superseding this labor by means of harrowing; but they must have been peculiarly fortunate in choosing the precise moment when the weeds could be completely destroyed by this operation, without injury to the young plants just emerging from their seed.

When the carrots show themselves by their cut leaves, it is indispensably necessary to rake, hoe, and thin them: the hoeing must be repeated twice at least. By the first operation the carrots are left somewhat too close together; but, by the second, they must be thinned till they are at least nine inches apart. It is almost incredible to what an extent the success of the carrots depends on the performance of this operation. I have repeatedly made a comparative experiment, and seen others do the same, by treating one-half of a field according to the gardeners' method, that is to say, first pulling up the weeds and then a portion of the carrots to thin them—and hoeing the other half at the proper time. The portion treated by this latter method yielded at least three times as much as the other. But the hoeing of carrots requires practice and attention, and therefore renders their cultivation difficult and costly.

It is, however, worth the trouble; for, by means of it, the crop of carrots may be made to amount to 300 scheffels per acre, and even more.

If it be impossible to devote so much attention to the cultivation of the carrots, we must content ourselves with smaller produce. In such a case, it is better to sow them among some other plant, and take them as a second crop: they are well adapted for this purpose, since they do not spread till the latter part of summer. They are usually sown among poppies, which are removed in tolerably good time. After poppies, early flax is best adapted for sowing with carrots, because, when pulled up, it leaves the soil clean and light for them. It is also said that carrots may be sown among rye; but if so, it must be necessary to hoe the stubble immediately after harvest, in order to remove it; and leave to the carrots a sufficiency of room and a lightened soil. This operation is required in so busy a season that I have not yet been able even to try it; if it were omitted, the carrots would certainly fail. It will be understood that carrots sown among other plants require a richer soil than when sown by themselves.

The leaves of carrots are cut at Michaelmas; but cattle do not like them; they even prefer potato haulm.

Carrots are best taken up with an iron fork; the leaves are usually cut with a scythe. Some persons say that they keep better when the tops are removed by twisting. It is certainly at the point of separation that carrots usually begin to rot: it is, therefore, proper to allow this part to dry and cicatrize before the carrots are taken to the store in which they are to be kept during the winter. It is advisable also to leave the carrots for a certain time on the ground, in small heaps, in order that they may be washed by rain.

Carrots are not injured by moderate frost; but, when severely attacked by it, they are very apt to rot after a thaw. On the other hand, when they are put in large heaps and kept very warm, they soon ferment and rot. It is, therefore, somewhat difficult to keep them during winter. The safest method is to place them in layers alternating with straw, either in cellars, or in stacks or heaps, which, on the approach of severe cold, are covered with straw and then with earth, in the same manner as potatoes; care must be taken to admit the air as soon as the weather becomes mild. When carrots are kept in pits, it is not safe to put more than a few bushels together.

Carrots afford excellent nourishment for all kinds of live stock. For this purpose they are better than any kind of turnip, and, according to the experience of many agriculturists, they agree very well with pigs; they are even somewhat superior to potatoes, which, nevertheless, contain a great quantity of solid food. In my part of the country, they are regarded as absolutely the best food that can be fed to pigs. An anonymous writer in the "German Agricultural Gazette," has lately maintained that carrots are injurious to the formation of milk in horned cattle. It is scarcely conceivable how data assumed at hazard could produce so much effect as those of the author in question have produced. Other persons, however, relying on their own experience, have successfully refuted the assertion. Carrots *have a highly beneficial effect upon milk!*

It has long been known in our country that carrots are eagerly eaten by horses, and are very wholesome for them; in consequence of which they have been adopted as a remedy for horses

* To avoid this inconvenience, and gain more time for preparing the soil intended for the carrots, I am in the habit of spreading the seed (after it has been rubbed between the hands in the manner above described, and mixed with shavings) on a table in a warm place, but protected from the direct rays of the sun. It is then constantly watered with stable-drainings, for 8 or 10 days, in order that it may be ready to germinate as soon as it is put into the ground. To prevent the upper portion of the seed thus spread out from drying too quickly, and becoming deteriorated, instead of germinating, I cover it with a small quantity of ashes, by which means the moisture is more completely retained. I also take care to keep the seed constantly moistened up to the time when it is put into the ground, and then to cover it up. [French Trans.

which have been overheated. But, as I have observed in the first volume of my "English Agriculture," the English, and particularly the Suffolk cultivators, were the first to show that horses may be kept in full vigor for six months upon this food, although they are employed in the most laborious occupation. A horse requires 70 or 80 lbs. of carrots per day, besides 8 lbs of hay.

The Parsnip.

This plant requires for its complete success a soil even richer and more humid than that required for the carrot. Its cultivation is almost entirely similar to that of the carrot, but somewhat easier; for the parsnip gains strength more quickly, soon puts forth its large leaves, and is not so easily choked by weeds. It is also more easily drilled, because its seed is more uniform. But it absolutely requires thinning, without which it gains but little strength.

On a rich soil well stored with humus, the produce of the parsnip surpasses even that of the carrot. In point of nutritive power these two plants are, perhaps, equal; some persons even think that the parsnip has the advantage in this respect.

An advantage which the parsnip possesses over all other root-vegetables, is that, when left in the ground, it completely withstands the attacks of frost, so that it may be kept for spring consumption. It therefore deserves more attention than it has hitherto received. Vide "Annalen des Ackerbaues," bd. iii. s. 294.

Parsnips, as well as carrots, may be sown among other plants.

The abundant leaves of the parsnip are very grateful to cattle, and, if I can trust the limited experiments which I have made upon this subject, increase the secretion of milk. It might, therefore, be advantageous to cultivate this plant merely for its stalks, which always grow again after being cut, and take root almost as easily as weeds.

Maize, or Indian Corn (Zea mais).

This plant belongs by its nature to the cereal grasses, and by its cultivation to hoed crops: it is for the latter reason that we treat of it in this place.

Maize requires a warm and rich soil, the former quality being requisite in proportion to the coldness of the climate in which the plant is grown. A soil which is both sandy and calcareous, and mixed with a small quantity of argillaceous matter, is better adapted for maize than a tenacious, plastic clay; especially if the former be well supplied with manure. For the cultivation of this plant the land should, if possible, slope toward the south, and be sheltered from the north-west wind. The culture of maize is much less precarious in southern climates; it may, however, succeed in ours, provided we are not frightened by failure in cold summers. In 1805, the larger variety failed altogether in this country, and the smaller scarcely attained maturity. In 1810, the cold which happened toward the end of summer caused the maize to fail.

The varieties of maize are innumerable; but they are not permanent, and easily blend one into the other. The color of the seed is particularly changeable; but, in an economical point of view, this appears to be a matter of indifference: diversity of size is of more consequence.

The maize which is cultivated in the Southern States of North America grows to an enormous size. In one experiment made with this variety, some seed was sown in a bed which was situated on the south side of a house, and had been plentifully manured for the cultivation of flowers. The maize reached, with its male flowers, the windows of the second story, a hight of at least eighteen feet. It was a magnificent plant; but although the summer was tolerably warm, not a single grain ripened. This variety is, consequently, quite unfit for cultivation in our country.

The variety most frequently cultivated in Europe is that called the large maize: when successful, it yields a considerable crop. Lately we have been made acquainted with the small variety, which, under the names of *quarantino, cinquantino, sessantino,* and *torquetto,* is cultivated in Italy as a second crop. It has been recommended for cultivation in this country, because it may be sown late, completes its vegetation during the hottest season of the year, and therefore appears well adapted for cultivation in northern climates. But according to all the trials which have been made of this variety of maize, its produce is too scanty to repay the trouble of cultivating it as a separate and principal crop. It easily mixes, however, with the larger maize, and produces a hybrid variety, which appears to be the safest and best adapted for cultivation in our climate, though we must not expect it to yield a produce equal to that of the larger variety.

Maize requires a soil carefully and deeply cultivated, and having a vegetable stratum well stored with manure.

It must not be sown till we can predict with some confidence that no frosts will happen after it has come up. In this country much apprehension is with reason entertained of the dangerous days of the middle of May, and therefore the maize is sown at such a time that it cannot come up till after that season. Some persons maintain that maize is not very likely to be injured by frosts which may attack it in the first stage of its growth: for my part, I have continually seen maize-plants which have been seized by frost remain sickly, although they have not been killed.

Maize is cultivated by the gardeners' method, with great labor, and in various ways: but I here confine myself to describing the horse-hoe cultivation, the only method by which this plant can be adapted to large rural undertakings.

The seed may, like that of beans, be deposited in the row by means of a bean-drill, to which is adapted a cylinder, proportioned in size to the work which it is to execute, and the size of the maize seed: but the furrow must have very little depth, not exceeding three inches: moreover, this method must be adopted only on sandy soils. A safer plan is to trace with the marking-plow the furrows in which the seed is to be deposited, making them about two inches deep: this is done by pressing lightly on the instrument, so as to make it penetrate somewhat more deeply than usual. The seed is then deposited in the furrows, and covered by harrowing the soil with a harrow turned upside down.

The seed sown by the bean-drill is closer together than the plants can be allowed to remain. As soon, therefore, as it has sprung up, the superfluous plants are removed with the hand-hoe, the

weeds which have come up between the rows being destroyed at the same time. In this manner the large maize is thinned to the width of 15 or 18 inches, and the small to that of 6 or 8 inches: the distance between the rows is usually 2 feet.

The spaces between the rows are first cultivated with the horse-hoe; and then the plants are earthed up, slightly in the first instance, but afterward strongly.

When maize is about to flower, the young shoots which come out near its lower leaves should be pulled off. These shoots, if suffered to remain, will not indeed injure the plant; but they are of no benefit to it, and may, therefore, be advantageously used to feed the cattle, for which purpose they are excellent.*

As soon as the maize has fairly flowered, it is to be left quiet, otherwise the fructification of the female ears, which at this time put forth their long, tuft-shaped pistils, might be disturbed.

When the fructification is complete, which is known to be the case by the withering of this tuft, the male flowers are cut off, in such a manner, however, as to leave one leaf attached to the stem above the female ear. The small and imperfect ears are at the same time removed, not more than three being left on each plant, because the rest would not ripen at the same time, and would merely deprive the rest of nourishment to no purpose. It is true that the fructification of all the ears does not take place at once: but the male flowers should be cut off when almost all the ears have been fertilized. The removal of these parts of the plant supplies a quantity of fodder as substantial as that of any other green plant, and which may be used sparingly in conjunction with other kinds of fodder. It would be inconsistent with good management to pinch off the tops of all the maize plants at once, and give them to the cattle in very large quantities. The gathering should not be performed all at once, excepting when this part of the crop, which contains a great quantity of saccharine matter, is to be used for the preparation of syrup or sugar.

From this time the maize is left to itself to ripen, no more being done to it till the seeds become hardened. There is no fear of their becoming too ripe and detaching themselves from the ear: but they are much exposed to the attacks of the crows, which often assemble from the whole country round to feed upon a field of maize. This circumstance renders it necessary to gather the crop as soon as the seed is ripe.

The ears are taken into buildings, and stripped as soon as possible of the leaves with which they are enveloped. The preservation of these ears till they are perfectly ripe is the most difficult part of the culture of maize. The method usually followed is to leave two of the largest leaves attached to each ear, to connect them at their extremities, and pass a thread through them, by which they may be hung up in the granary. Some cultivators use for this purpose stoves surrounded with hurdles, and keep them at a very high temperature. The method best adapted for preserving maize, and most easily applied on a large scale, is to keep it in open granaries, into which the air can enter—such as are described and delineated in Dr. Burger's excellent work on the culture of maize.

When the ears are perfectly dry, which, unless the stove be used, does not happen till January,† they may be threshed as easily as other grain plants; those ears which are intended to furnish seed for sowing should be emptied by hand, to prevent the seed from being injured.

The straw which has been left standing must next be cut off above the root; if not wanted for any other purpose, it will furnish very excellent fodder. It is said that syrup may be prepared from the stems of maize as well as from the grain of the ear. Some say that the best mode of turning the stems to account is to reduce them to ashes, for the sake of their potash, of which they contain a considerable quantity.

The grain of maize affords very substantial nourishment. In many countries it forms the principal food of man, even without being made into bread: it is not fit for this latter purpose unless it be mixed with other grain. In some countries it is used solely for feeding cattle, and is considered to be the most efficient of all kinds of food that can be employed for fattening domestic animals of all kinds. In almost all places where it is cultivated on a small scale, its efficacy in fattening poultry is well known; it is given to the poultry either whole, macerated, cooked or ground. The unthreshed ears are often given to pigs; maize which has not attained its full maturity may always be advantageously used in this manner.

As maize requires thinning to a certain width, it is often considered desirable to grow some other plant which rises but little above ground in the intermediate spaces. Beet is generally chosen for this purpose, and sown as soon as the maize has been earthed up. I must say, however, as the result of my own experience, that the beet which I have obtained in this manner has always been small, and has ill repaid the labor bestowed upon it. I have derived much greater advantage from sowing small haricots at the same time and in the same rows with the maize. Dr. Burger has contrived a modification of the bean-drill, which is very convenient for executing this double sowing. The box containing the seed is divided into two parts by a partition, and the cylinder has holes adapted to the size of the maize on one side, and of the beans on the other, so that the machine sows maize and haricots alternately, when these seeds are deposited in the spaces intended for them. The seed will not indeed be distributed with perfect regularity, but the plants may easily be thinned to the proper distance by the use of the hoe.

I have not thought proper to dilate largely on the culture of maize, because we have recently been furnished with two complete works on this subject, viz., the complete, ingenious, and admirable treatise of Dr. Burger—"*Ueber die Cultur und Benutzung des Mais*; Wien, 1809 ("On the Culture and Application of Maize; Vienna, 1809."); and *Anweisung zum Anbau und zur Benutzung des Mais, besonders im Nordlichen Deutschlande und den Preussischen Staaten; nach eigenen Erfahrangen, von Hofprediger Schregel zu Schwedt.*" ("Directions concerning the Culture and Application of Maize, particularly in Northern Germany and the Prussian States,

* Good, certainly, but not very good for milk. [*French Trans.*

† This observation is applicable to northern countries only; in the south, maize is gathered and threshed as early as August. [*French Trans.*

compiled from personal experience, by Schregal, Court-chaplain of Schwedt"). The latter work has been printed both in the ninth volume of the *Annalen des Ackerbaues*, and likewise separately (Berlin, 1809). I take it for granted that every one who wishes to devote himself in earnest to the cultivation of maize will avail himself of one or other of these treatises.

Doubtless, however, in these, as in all other special treatises, the subject is exhibited on its fair side only, the chapter of accidents being left in the dark.

The use of unripe maize for the manufacture of sugar has lately been again recommended, on the ground that maize is better adapted for this purpose than beet-root. I have long been of opinion that of all plants which can be raised in this country, maize is best suited to the purpose in question; the syrup extracted from it is, before crystalization, decidedly superior to that of beet-root.

In the south of France, and in Italy, maize is also cultivated as a fodder plant, and either given to the cattle, in the green state, or made into hay, just as the tufted pistils begin to show themselves. It is sown broadcast, but afterward hoed and thinned, so that the plants may receive a second hoe cultivation. and be slightly earthed up. The drilling machine might, however, be used for this purpose, in order to make the hoe culture practicable with horse implements. The maize is mown close to the ground; it is not easily dried, but is well adapted for use as green-meat.

In these warm climates, maize is cultivated for this purpose as a second crop: in ours it would be only in summers and autumns like those of 1811 that this plant would attain sufficient strength and size when sown upon rye stubble. It might, however, succeed after a crop of colza. The success of the smaller variety would be certain. But on the fallow, or the hoed-crop field, maize would be as appropriate as any other fallow plant intended for fodder: an early green crop might also be previously raised on the same spot, if it were desirable to turn the land to the greatest possible account. The produce of maize as a fodder plant would probably be equal to that of many others both in quantity and quality, especially when grown on well manured sandy soils; but I am not acquainted with any exact experiments on this subject.*

HERBAGE PLANTS.

Common purple Clover (Trefolium Pratense, var. Sativum.)

It has long been known to agriculturists that this kind of clover, which is preserved in our country only by cultivation, is different both in nature and appearance from that which grows wild in our meadows, though botanists have always regarded them as the same species. Botanists have, however, been also obliged to acknowledge this diversity, for they have noticed a difference of proportion in the structure of the several parts of these clovers.

But the clover which we procure from seed likewise comprises two distinct varieties at least. The one which has been hitherto but little cultivated in our country, but is elsewhere known by the name of *green clover*, is characterized by slower vegetation, greater strength and abundance of leaves, and a larger proportion of the green parts to the flowers. It flowers later, attains greater hight and strength before it ripens, and may therefore be left standing for a longer time; whereas common clover flowers more quickly, and may be mown earlier, if we do not wish to wait till it becomes hardened by perfecting its seed. I have had the former kind in my possession, but it was accidentally destroyed. I have now got a new sample, and intend to make more accurate observations on it. According to the statement of those who are acquainted with its properties, this kind of clover is very useful, especially for stall-feeding cattle, because it retains its nutritious matter longer than common clover. and grows to a larger size.

Clover is said to thrive on all soils, even those of a sandy nature, provided it be well supplied with manure. This is true; clover will grow even on soils containing eighty per cent. of sand, provided they are well stored with nutriment, plowed deeply, and cleared of weeds, at least of the perennial species: provided also, that the land be in a low situation, or the growth of the clover be favored by a wet summer. By careful cultivation, land of this description may be made to produce very fine clover, if the weather be not unfavorable. But on soils which contain a greater quantity of clay, and are at the same time calcareous, clover requires less careful cultivation, and in dry seasons is much less precarious. At all events, there is no reason to fear that clover grown on such soils will dry down to its very root. On a marly and vigorous soil clover is, as it were, in its native abode; nothing is required beyond the spreading of the seed: the clover gets the better of all the plants that grow around it. But on a sandy soil. totally destitute of lime, and somewhat disposed to acidity, it is necessary to remove any obstacles that may present themselves. sow the clover after recent manuring, and especially to favor the extension of the roots by deep plowings, in order that the plant may be less exposed to injury from the desiccation of the surface.

In consequence of these circumstances the cultivation of clover is in some countries very easy, and may be made to occupy any place that may be desired in the rotation. There are localities, though they are seldom met with in Germany, where clover may take the place of the fallow every three years, and will leave the soil clean and light. But in most situations clover requires a select and well-prepared spot; and it is really worthy of such selection, on account of its great utility.

The culture of clover had long been known, and had become extended, though only in isolated enclosures or gardens, when *Gugenmus*, and *Schubart, of Kleefeld*, among others, recommended its extension over whole fields, and its mixture with the cereal grasses. Since that time clover has been regarded and used by many persons as the basis of Agriculture, and the pivot on which

* During the summers of 1813 and 1814, my cows in Italy were frequently fed upon green maize; and my people constantly observed a diminution in the quantity of milk, when cows previously fed on clover or lucerne were put on maize diet. Moreover, this plant is exhausting even when mown in the green state. [*French Trans.*

it should turn; but with various results, according to the nature of the soil, and perhaps, also of the climate. The greater number of cultivators were for a while obliged to confine themselves to the practice of now and then turning the fallow-field to account, by means of this cultivation. Others were compelled to abandon it altogether, or at least to fallow after their clover, before they again devoted the soil to the growth of cereals, because it had become hardened and infested with herbs during the growth of the clover. Finally, the system of alternate culture has assigned to clover a place in which it is sure to succeed, even on a soil not well adapted to it, provided the weather be not extraordinarily unfavorable to it. In this place clover yields an advantageous produce, and, at the same time, maintains the soil in a favorable condition for the following crop. By labor —by the removal of weeds and the deepening of the vegetable stratum, which have been effected in the year preceding that in which the clover is sown—the soil is prepared in such a manner that the clover is enabled to cover the whole surface, and put forth its shoots without hindrance from other plants. It is only in this manner that the soil for the succeeding crop will be kept clean and light as when the clover was sown.

At the present day clover is no longer sown alone, but mixed with some other plant; for it rarely yields a very large crop in the year in which it has been sown, and in the early stage of its growth it is much assisted by the protection of another plant, which may afterward give up the ground to it. The sooner the plant with which the clover is mixed abandons the soil or is mown, the greater is the strength gained by the clover. This plant is usually sown among corn; formerly it was always mixed with the spring grain, but at present it is commonly mixed with the autumn grain, and in most cases with equal success, provided the sowing be performed with proper attention, and certain precautions which we shall presently notice. Clover is not sown at the same time as the autumn grain, but at such a time that it may germinate after the winter season. It is sometimes grown among peas, and certainly shoots forth with great vigor among the stubble of those plants. But if the peas are soon laid, and do not ripen quickly, the clover may be completely choked by them; its growth will then be very unequal, presenting large vacant spaces here and there. We are, however, acquainted with two plants which are altogether favorable to clover sown among them, and likewise to other plants possessing a certain degree of affinity with it; these are flax and buckwheat. These plants favor the germination and early growth of the clover, and allow it, much better than corn, to thicken and establish itself uniformly on the land.

Flax is no longer sown, excepting on rich and well prepared soils; it is cleared of weeds, an operation which is productive of benefit to the clover. The latter is not injured by the pulling up of the flax, if this operation be performed with proper care. But among buckwheat I have seen clover growing thickly even on a soil which was not well suited to it. Close by its side, and on a somewhat better soil, there was a crop of oats growing mixed with clover; and thus I had an opportunity of convincing myself in the most positive manner of the great difference between the two crops of clover, and the superiority of that which grew among the buckwheat; this superiority was maintained during the whole of the following year. I would, therefore, recommend the cultivator who wishes to have a thick crop of clover, and does not think his land very well adapted to it, to sow his clover among buckwheat. It appears to be indifferent whether the buckwheat be allowed to ripen, or mown to be consumed as green-meat. Clover also thrives well among colza.

Clover may be sown from the beginning of spring (or even in winter, provided that it do not germinate) till the beginning of August. If it be sown later, and come up before the end of autumn, it is commonly destroyed by the winter. It is particularly important to obtain favorable weather for sowing, so that not only the grain may germinate, but likewise the young plants may not be in danger of perishing from drouth, or the attacks of aphides. For these reasons, the surest clover-sowings are those which are executed very early in the season, or else among the autumn grain, on even ground not exposed to be flooded, and even while the land is covered with snow (the melting of which carries the seed down into the ground), or among large barley sown very early, for the clover is then benefited by the humidity of winter. If the soil has but just sufficient moisture to enable the seed to germinate, and this moisture be then exhausted by long continued drouth, no rain coming to the assistance of the clover, and the plants are in consequence unable to gain strength, the crop is almost sure to suffer. It would be safer to sow it on a perfectly dry surface, where it might remain without germinating till wet weather came on.

The degree of care required in sowing clover depends greatly on the adaptation of the soil for it. On a favorable soil, the seed may be scattered in any way whatever; the clover is sure to come up. But if the soil be not of the proper character, we must be very careful in sowing, and not allow ourselves to be guided by the opinion of a few fortunate cultivators of clover, who think that care and attention are quite unnecessary. It may occasionally happen that a sowing performed in a very unequal manner may be especially favored by fine weather; but at other times this unequal sowing will be productive of a great deal of mischief, which will more than counterbalance any good that may occasionally result from it.

Clover-seed must not be buried under a thick layer of mould, but placed permanently in contact with a stratum of light soil. When the soil is lightened, and the seed covered up with the harrow, part of it becomes buried to too great a depth, and is choked by the earth which covers it; it should, therefore, be well spread after harrowing. Even when the crop among which the clover is to be sown has already grown up to some hight, and especially if it be an autumn grain, the ground must be harrowed before sowing the clover, in order that the crust on the surface may be completely broken, and the cracks which are formed in it may be closed up. The clover is then sown without delay; and if it be desired to proceed without chance of failure, the roller is passed over it. In this manner the clover falls into the furrows made by the teeth of the harrow, and is afterward covered up with a light stratum of earth, which the roller compresses upon it. The same method is pursued when clover is sown as soon as the grain of the corn crop has been put into the ground; and even if it would not otherwise be thought necessary to pass the roller, this operation must be performed for the sake of the clover. On a very light, porous soil, well filled with humus, clover must be sown before the surface has been completely leveled by the harrow

and the harrowing must be performed a second time to bury the seed. On soils of this description clover shoots up through the earth which covers it; but, if left on the surface, it is unable to withstand dry weather.

Some cultivators, in sowing clover among spring corn, wait till the latter had come up, in order that it may not be choked by the clover. This accident, however, is not likely to happen, unless the soil be particularly favorable to the growth of clover. In one instance, however, I witnessed this occurrence. The soil on which it happened was not very well adapted to clover: but it was in a low situation, and the spring of the year was very wet. The barley sown on this land had suffered so much from moisture that it would certainly have failed, even if no clover had been mixed with it.

In general, then, I should recommend that clover be sown as soon as the spring corn has been put into the ground; if it be deferred to a later period of the season, the ground will require harrowing—an operation which may be injurious to the young barley.

It is of great importance that the seed be well spread, in order that the clover may not be too thick in one place and too thin in another, or leave vacant spaces. For this purpose it is well to divide the seed into two portions, and sow one along the field and the other across, unless, indeed, we can procure a sower well practiced in this kind of sowing.

There is much diversity of opinion respecting the quantity of seed required. Some persons consider 4 lbs. per acre sufficient; others recommend 10 or 12 lbs. I am aware that the former quantity is capable of producing a very thick field of clover, but only under very favorable circumstances. Even if everything has been duly prepared, and a skillful sower can be obtained, I should still recommend 6 lbs. per acre, and, if these conditions are not completely fulfilled, 8 lbs. —for, whatever saving of seed may be effected on a large extent of ground, it is as nothing when compared with the disadvantage of having a field of clover scantily and unequally covered. I shall hereafter speak of the qualities which the seed ought to possess.

The clover will often appear thin at first, even though the crop among which it is sown may have been gathered. This is not of much consequence; but the clover ought to make its appearance a fortnight afterward, or, at least, as soon as rain has penetrated the soil. If the clover come up among stubble, it will often become large enough to afford a crop. If this happen before the middle of September, we need not hesitate about mowing it. At a later part of the season, there would be danger of sudden cold, which would arrest the growth of the plant to such an extent as to leave it too weak for encountering the winter. The usual mode is to have it fed off, which may be done without injury by the horned cattle till the end of September. It may also be cropped by the sheep, but not quite close to the ground, as the animals might then attack the crown of the plant and destroy it. There is sometimes too much and sometimes too little apprehension entertained of this accident.

Clover may be destroyed by winter: it is more or less exposed to this danger in proportion as the soil is more or less adapted by nature and cultivation to its wants. On a deeply cultivated soil, clover will resist winters which are fatal to that which is sown on more superficial soils. I noticed this in the winter of 1802–3, when the frost penetrated to the depth of three feet below the surface. In the winter of 1811–12, the clover perished on all dry, sandy spots, while it maintained its ground on humid soils; but this appeared to result from the extreme desiccation which the soil had undergone toward the end of summer, rather than from frost, which in that winter was not particularly severe. Even when the clover does not make its appearance after the cessation of frost, there is no reason to despair; but if, on the other hand, a few plants come up, and yield easily to the hand, leaving their roots behind them, there is but little hope of the crop. I have indeed observed, in a manner which leaves no room for doubt, that such plants will sometimes take root again, and shoot forth vigorously; but this takes place only under very favorable circumstances.

Clover is sometimes covered during winter with dung containing straw, both to give it strength and protect it from the cold. At the present day, however, experienced cultivators do not follow this practice, because the dung often makes the clover weakly, and attracts mice, and may, therefore, be more injurious than useful. Moreover, the circumstances of a farm in general do not admit of this use of stable manure. If it be desired to help the clover a little, dirt collected in the farm-yard during winter may be put upon it, or it may be watered with liquid manure. In spring the crop may be greatly benefited by manuring with turf, or soap-boilers' ashes, or a compost prepared with lime. But the most common manure for clover consists of powdered gypsum spread upon the land when the clover begins to grow.

Harrowing in spring when the clover begins to shoot forth is a very useful operation, and will repay the expense which it occasions. The more forcibly this harrowing is performed, the greater is the benefit which it confers on the clover.

The proper time for mowing clover is when the field begins to assume a purple hue from the expansion of the flowers. If the clover be mown earlier, the crop will be considerably less, for it is at this time that the clover grows most rapidly—so much so, indeed, that a week may make a difference of one-half in the amount of the produce. If the clover be mown later, the crop will be still more abundant: but the stems will be hard, the whole substance will contain a greater portion of insoluble fibrin, and the following growth will be weaker. It is only when clover is to be used for stall-feeding cattle, and forms the basis of this system of feeding, that it should be mown as soon as it will bear the scythe; the portion which has been mown early will then have time to grow again by the time when the first crop can no longer be left standing. We shall say what remains on this subject when we come to treat of the stall-feeding of cattle.

Clover may be intended to grow and be cut during one year or two. It would be useless to leave it standing for more than two years, unless it were to be used as pasturage; because, in the third year of its produce, or the fourth from its sowing, it undergoes considerable diminution, and its place is supplied by grasses. The question as to whether it should be turned to account for one year or for two, must be determined by the particular circumstances of each rural estab-

lishment, and by the time during which the clover will thrive on the soil—a point which experience alone can decide. It has been remarked that there are some lands on which clover is very fine during the first year, but dwindles remarkably in the second; while on the others it shoots more abundantly, and is thicker and more uniform in the second year than in the first. The second of these cases seems to occur on soils of which the vegetable stratum is deep, but which are not much disposed to produce grass; the first case, on the contrary, when the soil has but little depth, and is favorable to the growth of grass. Nothing, however, but extensive observation will enable us to deduce any general conclusions respecting this matter, since it is possible that in those cases from which my observations have been drawn, the culture which preceded the sowing of the clover, or some peculiarity in the weather, may have had an influence on the duration of the clover. For the present, every one must be guided by his own experience as to whether it is advisable for him to let his clover grow for one year or for two.

Clover generally yields three crops. The first is commonly the most plentiful, the second somewhat less, and the third least of all. But this rule is liable to frequent exceptions, because the strength of each shoot depends upon the weather. When a shoot continues weak in consequence of dry weather, it is the worst thing that can be done to leave it standing beyond the usual time, in the hope that it will grow more vigorously when rain comes on. It should, on the contrary, be immediately cut down, especially if there be reason to hope for more favorable weather, in order that the following shoot may be thicker and more uniform. It is rarely that three abundant crops are obtained, and still more rarely that they all fail; in most instances the goodness of one makes up for the deficiency of the others. I have often seen the second crop surpass the first, and, on one occasion, I found the third to surpass the other two.

When clover is left standing for one year only, which practice, however, is confined to the three-field system,* only two crops are commonly obtained from it: the third is buried with the plow, and the winter corn sown upon this single plowing. Every one knows that this third crop is a valuable enrichment for the soil, and that the autumn grain, especially wheat, thrives remarkably well on this single plowing. But the third shoot of clover is often so considerable, especially when the others have been mown early, that it is of great use in the general economy, particularly in localities where the supply of fodder is not greater than is required, and, consequently, no one is willing to sacrifice it. It is not advisable to sow autumn grain after a third crop of clover;† it is better to substitute a crop of oats sown in the following spring. This crop is always highly successful after clover, and, according to all my experiments, equally in value to the autumn grain.

When clover is left standing for two years, it is usual to cut it three times in the first year, and once only in the second: after that a summer fallowing is given. If the clover be thin and the land infested with weeds, this fallowing is indispensable; but if the soil be clean and well covered, two crops may be taken and the third plowed in; after which, we may proceed in the same manner as when the clover is left standing for one year only. The clover must not, however, be fed off by the cattle either in the first or second year. It is scarcely necessary to add that oats succeed remarkably well after two-years' clover; and if it be desired to turn the clover to the utmost possible account, I should recommend the sowing of oats, at least on those parts of the land on which the clover has not continued very thick to the last: for such spots must be plowed at least three times for the autumn grain, if we would not have the land infested with weeds.

Clover may either be consumed as green-meat or made into hay: it is well always to proceed with the view of making some portion of it into hay, even when it is cultivated chiefly to be used as green-meat in stall-feeding, for if there be a sufficiency under unfavorable circumstances, there must certainly be a surplus when the clover is successful. When we come to treat of stall-feeding, we shall inquire whether it is advantageous, as some persons think, to make the whole of the clover into hay, and feed the cattle on dry fodder during the summer.

There are various modes of making clover-hay: the state of the weather must determine which of them is to be preferred. In settled, fine weather, there is no better method than to leave the clover in swath until the upper portion is dry; and then turn it over with the handle of the rake, to bring the lower part uppermost. In order that the clover may not shed its leaves, it is collected in great heaps when the dew is deposited, and then carried to the barn.

But if the season be wet, and frequent rains may be expected, the clover will take too long to dry in swath, and even if it do not rot it will lose its flavor. In such a case, it is best to spread it after mowing, in order that it may dry more quickly, and then make it into cocks. On the morrow, after the dew is dispersed, these cocks are opened and spread, an operation which is most easily performed by hand: as the clover dries, it is collected into large cocks. If these cocks are much penetrated by rain, they must be turned over as soon as the rain has ceased, and the lower part brought to the top: this work is also performed by hand, care being taken to lay the hay down as lightly as possible, that the wind may blow through it. The cocks are made as high and narrow as possible, that the greatest possible quantity of clover may be protected from the rain, and at the same time exposed to the air. To enable the cocks to retain their upright position, it is very useful to fix small stakes in the ground, and heap the clover round them.

If any incipient fermentation or rise of temperature be perceived, the cocks must be turned and spread out. In wet weather this method is very troublesome; but it preserves the quality of the clover.

The third method is that described by F. J. Klapmeyer, in his treatise on the cultivation of clover and its relation to the growth of corn. (*Von Kleebau und dessen Verbendung met dem Getreedebau.* Riga und Leipzig, 1797). It is commonly known by the name of Klapmeyer's

* This is the case in most crop systems in which the land is not laid down to grass, and particularly in that of Norfolk: 1, turnips; 2, barley; 3, clover; 4, wheat—or, in ours: 1, potatoes, or other hoed crops; 2, wheat; 3, clover; 4, wheat; 5, hoed beans; 6, wheat; 7, clover; 8, wheat—also in most well arranged crop systems.—1815. [*French Trans.*

† In the north, certainly not; but it may be done in our country. [*French Trans.*

method. It may be recommended particularly for adoption in very rainy weather, diversified with intervals of fine.

The first method is preferable in perfectly dry weather; the second in a season of continued rain. Klapmeyer's method is as follows:—The clover mown on the preceding day is raked into small parcels at four o'clock in the afternoon, and afterward gathered into very large cocks, each containing several cart-loads: they should be carefully made up and well pressed. If the night be calm and warm, fermentation will set in after the lapse of four or five hours, and show itself by a smell resembling that of honey. On the following morning the interior of the heap will be very hot, and on opening it vapor will be disengaged. This is the time for spreading and turning over the clover with rakes and forks. If the sun shine, or a little wind come on, the clover will be dry enough by the afternoon for removal into the barn, or, if there be not time for that operation, it may be again made up into cocks; there will be no fear of a second fermentation.

If the night be cold, windy, or rainy, fermentation will take place equally well; but more time will elapse before the heat becomes too great to permit the thrusting the hand into the heap, which is the sign by which we know that the fermentation has attained its maximum. If the wind be very high, fermentation will take place on one side and in the middle, but not on that side which is exposed to the wind. In this case, the cock must be opened, and the fermented clover spread out; it is easily recognized by its brown color: the rest must be immediately heaped up again that it may ferment. If the fermentation should have affected a small part only in the middle, the clover may be again cocked, the green part being placed in the center, and the brown on the outside and at the top. We must then wait till it has fermented, and spread it out again. If the portion of clover which remains green and has not fermented be very small, it is said to do no injury to the rest when the whole is carried into the barn. If it be desired, however, the green portions may be separated and left behind.

If a heavy rain should come on while the clover is in a state of fermentation, it must, nevertheless, be spread out. If the rain continue, the clover must be stirred and turned again from time to time. Then, if the rain should cease for a few hours only, the fodder will soon be dry enough for housing, because moisture will not adhere to clover thus fermented. It will not rot, even though left exposed to the rain for several weeks, provided it be not removed before it is perfectly dry: its nutritive power will, however, be diminished.

The chief advantage of this method is that the clover dries very quickly, and may be cut and housed within three days; whereas, by other methods, particularly when the crop is very abundant and the clover soft when mown, this course of operation takes at least a week. Clover which has fermented is already deprived for the most part of its internal moisture, and only requires external drying.

The properties of clover are certainly changed by fermentation: this is sufficiently proved by the sweet odor which it exhales: but it is not yet decided whether the quality is improved or deteriorated by the change. The advocates of the method assert positively that the quality of the clover is improved by it; they compare the fermentation to that of bread and to the sweating of corn, by which the substance of the grain is rendered more nourishing and easy of digestion. They say, too, that all kinds of cattle, as soon as they are accustomed to clover treated in this manner, become very partial to the taste of it, preferring it even to green clover; and that this fodder produces very rich milk and excellent butter. I cannot decide this question from my own experience: I tried the method once, but was obliged to absent myself while it was in progress; and my people fearing that the fermentation might proceed too far, opened the cocks too soon. Since that time, the weather has always been so favorable to the making of clover-hay, that I have not been inclined to adopt this method, which is very troublesome, in preference to one that is simpler. Trials on a small scale have appeared to me too little decisive, especially with regard to the effect which this fodder produces upon cattle.

According to information which I have received from many friends whom I consider impartial judges, this method is attended with all the success which is assigned to it; particularly in Silesia, where it is very generally practiced. It evidently requires great labor and attention, and when the crop is large, a considerable number of hands. In changeable weather, it is especially important to have the means of placing the hay under cover, as soon as it is sufficiently dried; for if it be alternately moistened and dried, it will be injured to an extent proportionate to the degree of its internal desiccation and the quantity of saccharine matter which has been formed within it.

Various other methods have been proposed for making clover-hay, not, however, practicable on the large scale; such as placing it on poles or hurdles under cover. I cannot, however, omit to mention a process which may sometimes be useful, though it is applicable to the large clover only, and may, perhaps, be even confined in its application to that which is raised from seed. It is as follows:—A quantity of clover is taken from the breadth, as much as can be held under the left arm, and tied up with a few of the longest stalks taken from it; the parcels so formed are set up in pairs one against the other.

It is said that clover thus treated does not spoil, even when long exposed to rain, and that it ultimately dries without alteration. This is the method adopted with buckwheat, in countries where that plant is grown.

For what remains to be said on this subject, I refer to my remarks on the making of hay, and its preservation under sheds or in ricks.

Young clover, mown just as it is going to flower, loses about four-fifths of its weight in drying completely; that which is in a more advanced stage of growth and in full flower loses but three-quarters; but the proportion is probably somewhat affected by the more or less humid state of the atmosphere during the time of growth. On the average, we may reckon that in the state of advancement which we have noticed as proper for mowing, 100 lbs. are reduced to 22 lbs.

The produce of clover is usually estimated in dry fodder, because it is much more difficult to weigh it in the green state. There is much diversity of opinion respecting the medium produce of clover: estimates vary from 16 to 50 quintals per acre; and there is certainly an almost endless di-

versity, according to the nature of the soil, and the cultivation and manure bestowed upon the crop. A friend of mine weighed the quantity of fodder which he had obtained in two cuttings from an acre of clover carefully measured, and on which the clover appeared to grow as thickly and strongly as I had ever seen: he weighed this fodder in a state of perfect dryness, and tied up in bundles, and found it to amount to 37 quintals 30 lbs. The soil was not peculiarly favorable to the growth of clover, but was in a state of great fertility, and had been manured on the surface with ashes from the soap-factory. I have, therefore, reckoned 40 quintals as the highest amount of produce that an acre of clover will yield in two cuttings. Since the time of which I am speaking, I have only once seen clover superior or, perhaps, even equal to the above: but, according to the descriptions which I have heard of that which grows in the most fertile regions, in Altenbourg for example, samples are to be found which far surpass it. I have now before me a specimen of clover from that country, which, as I am assured by eye-witnesses, has not been picked out as particularly fine, but rather taken as an average sample; it is in flower. three feet high, and has twelve complete stems. The lower leaves are, in the dry state, four-fifths of an inch broad and two inches long. I admit, then, that the produce of clover in dry fodder may far exceed 40 quintals per acre; but only under extraordinary circumstances.

In the first part of this work I mentioned 2,400 lbs. per acre as the average produce of clover on a sandy clay (good barley land), provided, however, that the clover occupied an advantageous place in the rotation, and one in which the soil was in good condition. This appears to me to be the nearest approach to truth, for land of this description.

In a well-organized rural establishment, the necessary quantity of clover-seed should be obtained from the land itself, for the purchase of it would not only be very costly, but also attended with many inconveniences. It is certain, however, that the soil is impoverished by the reproduction of the seed. This effect is not very obvious, but any one who wishes to convince himself of it has only to grow clover-seed for two successive years on the same land; if he do not supply the loss thus occasioned by manuring, he will see his crops continue inferior for several years on the spot where the seed has been gathered. The impoverishing of the soil is not, however, so great as to preclude the possibility of its being richly repaid.

The seed is usually taken from the second crop; in this case the first crop is mown rather earlier than usual. in order that the second may shoot forth more quickly and flower sooner. The first crop must not, however, be taken so early as to allow the backward shoots belonging to it to grow up after the mowing, for they would then get the start of the second crop, and ripen too soon. As, however, an unfavorable state of the weather may sometimes prevent the setting of the clover, and cause it to flower without forming seed, it is advisable, for the sake of additional security, to obtain a portion of the necessary seed from the first shoot, if its flowers are observed to set particularly well. The proper setting of the seed may be judged of by compressing the flowers between the fingers; they ought to be hard and to resist compression. It is best to reserve for gathering seed a part of the field on which the clover is not thick, but uniform and free from weeds.

The ripening of the seed should be as complete as possible. Some of the flowers get the start of the rest, and their seed falls to the ground in dry weather before the others have time to ripen; this inconvenience is experienced more with the first crop when the weather is hot, than with the second. We ought never to pay so much regard to it as to mow the crop before the greater portion of the plants are ripe, for even if a portion be lost by waiting, the produce will on the whole be greater than it would be if the crop were taken before it was all ripe. We may know when the clover is ripe by pressing one of the heads between the hands till the moisture contained in it is completely exhausted; the husk may then be separated by blowing upon it, and the seeds will rest in the palm of the hand. If the seeds be of a violet color, they are ripe; but this is rarely the case with all of them; they should be hard and convex, presenting no depressions.

Seed-clover should be mown in the dew, or, at least, not under a hot sun; it should be made into small cocks, and left till quite dry. It dries much more quickly than young clover. Care should be taken not to shake it in carrying, and to place it where it will be well exposed to the air, if possible, on poles, above the barn floor.

As soon as the clover is gathered in, especially if it has been housed in a state of perfect dryness, it is threshed, in order to separate the heads from the stalks on which they grow; this operation may, however, be deferred till the dryest frosts of winter. The husks separated from the straw are again subjected to the flail, and the seed thus obtained from them is separated by means of a sieve. What remains on the sieve is passed through the fanner, that the empty husks may be carried away by the air, an operation which greatly facilitates the threshing of the rest. This remaining portion is then taken to the barn, and spread out, for the sake of exposing it to the air and drying it well; it is then threshed again during dry weather, and the same process repeated.—This series of operations may be repeated three or four times without effecting the entire separation of the grain. This separation is accomplished much more easily when the heads are dried by artificial heat. The desiccation is usually performed in the kiln, but the seed is then very likely to burn, unless great care be taken, and the seed be not put into the kiln till the temperature is considerably lowered. If the heat be too great, the seed loses its lustre and assumes a brown tint. This color renders clover-seed very suspicious: the purchaser should look well to it. The safest method is to place a number of tables in a chamber which can be heated, and cover them with cloths, on which the clover may be spread: the room is then to be heated strongly for some days, care being taken to guard against fire.* When the quantity of clover-seed is sufficient to furnish a year's stock in advance, the best thing that we can do is to defer the threshing till the hottest days of the summer following. Such a provision is in every respect advantageous, inasmuch as clover-seed keeps perfectly well, especially before it is threshed. The clover, in its husk, is removed from the barn floor, and placed on cloths spread out in the sunshine; it is then several

* In our climate, in which the summer is longer, we have no occasion to resort to artificial heat for drying our seed clovers. [*French Trans*

times stirred with a rake, after which it is again carried to the barn floor and threshed. This is the easiest mode of separating the seed.

When a large quantity of clover-seed is gathered, it may be ground in the mill, but the mill-stones must be carefully adjusted in such a manner that they may not crush the seed. It is difficult to induce millers to do this in places where the operation is not common. We may usually obtain 300 lbs. of clover-seed from an acre of ground, and therefore realize a considerable sum by the sale of it, especially when we keep the seed which has been obtained in a plentiful season in order to sell it at a time when it is scarce and consequently dear. To save the trouble of threshing, many cultivators sow their clover in the husk; this method succeeds very well; the germination of the clover may indeed be retarded a little, but it will be rendered less precarious. But when clover is sown in this manner, we cannot guard against the seed being too thick in some places: and to ensure a sufficiency all over the field, it is necessary to sow twice as thickly as if the seed had been previously cleansed from its husk. The labor of threshing is undoubtedly tedious, but it is incomparably more economical than the use of so great a quantity of seed, particularly if we have the means of preserving or disposing of the surplus. The straw and chaff of clover are not nearly so valuable as young clover-hay; they may, however, be usefully employed in feeding cattle.

The observation that clover does not succeed when repeatedly grown on the same spot, is too general to admit of its being called in question. False rumors and prejudices do, indeed, spread in defiance of reason; but they do not, like this opinion, originate among several nations at once. Instances may, however, be found of clover having been sown for three or four years on the same land, and with uniform success. If now we examine the former cases with attention, we shall find that where the deterioration of the clover has been observed, the soil has been turned up to a small depth only; as, for example, in Norfolk, and in the duchies of Magdeburg, Brunswick, &c. On the other hand, where clover has been found to succeed uniformly, it has been sown in gardens, in the alternate system of four or five years, as in Belgium, for example. (Vide Schwertz, ch. ii. s. 4). In these situations the soil is once plowed up to a considerable depth between two sowings of clover. In places where the land is manured with lime, marl, or ashes, clover is not found to fail when often grown on the same spot. Gypsum, on the contrary, which is usually so beneficial to clover, is of no farther use in these cases. I content myself with stating these facts without attempting to explain them.

It has been often and warmly disputed, whether clover improves or exhausts the soil, and particularly whether it favors or injures the succeeding crop. Most persons incline to the former opinion; but it cannot be denied that many have experienced the truth of the latter. It has been positively ascertained that clover does not directly exhaust the land; for it is always observed that the success of the following crop is in proportion to the beauty and abundance of the clover, provided only that the latter has not been left to ripen and perfect its seed. The contrary would certainly happen if clover drew from the land a large portion of the nourishment by which it grows. But clover when thin and weak has a bad effect upon the soil, because it then permits the growth of weeds, particularly of dogs'-grass, and other grasses which have a disposition to spread. Moreover, the ground is hardened, from losing the beneficial shade of the clover, particularly when the clover, in spite of its poorness, is left standing for a long time, and the land which has borne it is plowed but once. If, then, we would obtain a good result from clover, in this respect also we must omit nothing which tends to make it grow thickly and strongly. It must be sown on a rich, well cleared soil, which has been lightened by fallowing, or the cultivation of hoed crops; the sowing must be performed with great care, and the crop mown at the proper time. The clover must then be plowed up, when it has grown up a little after the second mowing, and long enough before seed-time to allow the soil to settle itself, and the clover-stubble to rot. If, in spite of all the care bestowed upon the clover, it should grow but poorly, in consequence of unfavorable weather, and should be partly destroyed by winter, we must content ourselves with one crop, and fallow the soil with three plowings, succeeded by harrowing. When these rules are observed, the fertility of the soil will always be sensibly improved by the growth of clover, independently of the enrichment which it receives from the increased quantity of manure produced by the crop. Corn obtained after this plant is often finer than that which is grown upon a non-manured fallow.

White or Dutch Clover (Trifolium repens).

There are various kinds of clover which bear white flowers; even that of which we have been speaking sometimes changes color; but the name of white clover is almost always confined to the species of which we are about to treat. This species of clover is indigenous on almost all moist, clayey soils in our climate; it forms, indeed, part of the sward, and even if not perceived at first sight, it is soon discovered on closer inspection. It soon shows itself after the soil has been manured with substances congenial to its nature, such as lime or ashes—to such an extent, indeed, that some persons have imagined that its seed must be concealed in these substances.

Some cultivators also sow Dutch clover with the intention of mowing it; but it requires a very rich soil to cause it to grow to any considerable hight. On a soil of this description, it will sometimes yield a crop equal in thickness to that of the common purple clover, and, according to some persons, preferable to the latter as a fodder-plant—of better flavor, yielding more nourishment, and, above all, more conducive to the production of milk. But it yields only one crop, and does not rise much above the surface.

It is more frequently used to form pastures, and is certainly the most generally approved of all plants that are cultivated for this purpose. It is peculiarly fitted for a pasture-plant by the disposition which it has to send forth shoots, and the quickness with which its leaves are reproduced—a quality in which it surpasses the purple clover. Again: Dutch clover is not so easily choked by weeds, but exterminates them by means of its roots, which thrust their way through the soil; hence, it does not require a soil so well cleared, and may with greater facility be sown after repeated grain crops. It has also been remarked that Dutch clover is not, like purple clover, averse

to growing frequently on the same soil, although that soil may have been but superficially plowed —a consequence, no doubt, of the plant being indigenous, and growing spontaneously in this country. Some persons have, however, observed that on soils not very well adapted to its cultivation, it thrives better when first introduced than after the land has borne it for a number of years.

Purple clover is not found to be injured when sown alternately with white clover.

Dutch clover is sown either on the autumnal sowing or among the spring corn; but the former position is better for it, because among the autumn corn it grows up more quickly, and affords good pasturage among the stubble. It is also spread over the autumnal sowings as soon as the frost is over; sometimes also sown before winter, or even while the ground is covered with snow, in order that it may be more effectually buried by the water formed when the snow melts, and may consequently germinate on the first return of spring.

The smallness of the seed of Dutch clover, and the disposition of the plant to spread, allow of its being sown much more thinly than purple clover; a much smaller quantity of seed is therefore required for a given extent of ground—2 lbs. or 2½ lbs. per acre are quite sufficient, if the seed be uniformly scattered.

The time for which Dutch clover lasts depends upon the extent to which the soil is adapted to it. Sometimes it continues for three years only from the time of sowing, and fails in the fourth. When fed off to excess by sheep, it disappears sooner still, because these animals gnaw the stem even down to the roots, which they tear up.

When the seed is to be gathered, the clover is usually mown; this operation, however, always leaves many of the heads untouched. If it be desired to obtain a large quantity of seed from a small extent of ground, it is best to have the heads gathered by women and children, either by hand or with the scissors. The result of this method will always repay the expense of the manual labor. The seed may also be gathered by means of a sack having just within its mouth a kind of iron comb, which is drawn over the clover and pulls off the heads. These heads then fall into the sack, the mouth of which is for this purpose kept open with a bow.

Many other kinds of clover have also been recommended for cultivation.

Strawberry Trefoil (*Trifolium fragiferum*).

This species is very similar to Dutch clover, both in nature and appearance; it is distinguished from the latter only by its heads, which are in the form of strawberries. It is likewise indigenous, and appears to put forth leaves even more tufted than those of Dutch clover; but we are unacquainted with any trial of it on a large scale. The species known by the name of zigzag trefoil (*Trifolium flexuosum*), of which there are two varieties, *alpestre* and *rubens*, has been recommended as a substitute for the common purple clover, because both varieties thrive better than common clover on a bad soil; but their produce is less abundant, and they have not the soft fleshy leaves of the meadow clover.

The yellow melilot (*Trifolium melilotus*) approaches more nearly to lucerne than to clover, both in culture and mode of growth; it ought, indeed, to be regarded as a substitute for the former. The variety with blue flowers has too strong a scent; the yellow-flowered has less odor, and the white less still. The latter is, consequently, preferred. It, however, imparts a slight flavor to milk and butter; but this flavor is by some persons considered as not unpleasant, and in cheese is even esteemed.

Lucerne (*Medicago sativa*).

My attention has been fixed in an especial manner on this plant, on the one hand by the great esteem in which it has been constantly held, from the remotest times, as the best of all fodder-plants; and, on the other, by repeated attempts which I have made to cultivate it with all possible care, but which, in spite of all my endeavors, have produced but very indifferent results. I have not, however, confined my attention exclusively to my own experiments; I have also collected and compared the results obtained by other cultivators, and endeavored to trace the cause of the differences between them. I have, consequently, found reason to alter my opinion more than once, as may be seen by comparing the 1st and 3d volumes of my English Agriculture. At present, I consider myself better qualified to form a fixed and well-grounded opinion.

For the culture of lucerne, the lower stratum of the soil is one, I may almost say, of more consequence than the upper. The latter may be ameliorated and enriched during the growth of the lucerne; the former increases in importance every year, in consequence of the lengthening of the fusiform or principal root of the plant. For the subsistence of lucerne, it is absolutely necessary that the soil, to the depth of at least four feet, be of the same nature as the vegetable stratum, and in accordance with the habits of the plant itself. When the successive strata of the soil vary in consistence or constituent parts, the root of the lucerne is checked, and the plant dies, or, at all events, barley vegetates. That which is most inimical to it is a stiff clay on which water rests without penetrating. There are whole districts, as well as detached spots, in the fields where this variation of strata occurs, but at a depth which has hitherto concealed it from observation: in such situations all trials of this plant are unsuccessful. It is, however, possible to mix the several lower strata of the soil by turning them up, and thus to render them fit for the culture of lucerne: but the operation must be performed to a considerable depth, at least three feet below the usual depth of plowing; and even this is scarcely sufficient. I have often found, and my experience is confirmed by that of others, that lucerne, after having presented a remarkably good appearance until the third year of its growth, has then, instead of putting forth more abundant shoots, begun to thin and die away, notwithstanding that the greatest care has been bestowed upon it.

It is well known that a soil, to be adapted to the culture of lucerne, must not at any time of the year be exposed to injury from wetness. Spots which are over subterranean springs, and those on which water stagnates at the surface, occasioned by alternate strata of pervious and impervi-

ous soil, are on this account quite unfit for the growth of lucerne. Even if such portions of land could be properly drained, they would still be inapplicable to the culture of this plant. But lucerne is also injured by water running over the surface of the soil, and either collecting there, or filtering through. Such water injures the plants, either directly, or by favoring the growth of grass at the surface, which chokes and destroys the lucerne. This evil may often be somewhat lessened by draining.

The soil must also be of medium consistence. Stiff clay is quite unfit for lucerne, for only the vegetable stratum of such a soil is lightened by manuring and cultivation, and the lower stratum soon offers a resistance which is very injurious to the roots. Lucerne thrives better on a deep sandy soil, but continues weak and poor, and during drouth is so much injured that its leaves fall off. The best soil for lucerne is one which is homogeneous to a considerable depth, and in which the quantity of sand is to that of clay purified by washing in any proportion between 70 : 30, and 50 : 50. But it is still more advantageous to the lucerne when part of the sand is replaced by lime, even if that substance should be found in the lower stratum only, and not in the vegetable layer. The lime must not, however, predominate, or be collected in separate layers, but mixed uniformly with the other constituents of the soil. Sainfoin grows admirably on limestone, but lucerne does not.

The former kind of land, usually called *warm land*, is universally regarded as the best for lucerne. But the soil on which this plant grows should also have a warm aspect—that is to say, it should be turned toward the east, or the south, and somewhat sheltered from the cold, damp winds of the north and west. Lucerne is a native of warm climates: it there withstands continued heat better than any other plant: hence, warm, dry summers in which clover suffers most from drouth, are precisely those during which lucerne grown on proper soils yields the most abundant produce.

To cultivate lucerne successfully, it is necessary to turn up the soil not only on the surface, but likewise to a considerable depth: this mode of proceeding is much less costly and difficult than random trials, which seldom yield definite results. In various localities, where the lower strata of the soil vary considerably, the culture of lucerne is always precarious. Thick crops of it are rarely obtained on such soils: vacant spaces are always found; and in those parts where the plants meet with strata which are uncongenial to them, they fall off and disappear.

Land which is to be sown with lucerne must be well prepared, plowed as deeply as possible, and cleared of all perennial weeds; dog's-tooth grass, and all roots of grasses must be absolutely destroyed—a result which cannot be obtained more effectually than by a complete fallow, or the culture of hoed crops for two successive years. Annual weeds are not very injurious to lucerne, because they are cut down together with the crop which has been associated with it, or with the young lucerne itself, after which they disappear. Their seed must not, however, be allowed to ripen.

Before executing the labors required for lucerne, it is proper to manure the land abundantly, so that the manuring may not require repetition while the lucerne is growing.

Lucerne is sown either by itself or with another crop; the quantity of seed required is from seven to eight pounds per acre,* for the grain is much larger than that of clover. The former method was once preferred, because it gives greater facility of removing weeds, and thinning the lucerne where it looks too thick. But at the present, the latter method is almost universally adopted, because it is scarcely practicable to carry on the weeding operations on a large scale, and it has been found that the young lucerne plants are assisted by the covering and protection which they receive from those which are associated with them. Many cultivators sow lucerne with barley, especially the late four-rowed variety; the barley is allowed to ripen. Others prefer a crop which can be mown in the green state, such as peas, tares, and various mixtures. For my part, I prefer flax and buckwheat, which I have found by trial to be most advantageous; indeed, I have observed that under these plants lucerne always grows very thickly and uniformly, and afterward shoots with the greatest vigor. The flax must, however, be pulled up with some care and management, otherwise the young lucerne plants will be injured. Buckwheat may be either suffered to ripen or mown while in flower; but as on soils of this description it usually puts forth too many leaves to allow of its producing much seed, I prefer the latter method. Under these plants the soil becomes perfectly clean: they do not shoot a second time, but leave the ground to the lucerne at the very time when the latter is required to grow most rapidly. Toward the end of summer, and in autumn, the lucerne requires no farther attention.

Some cultivators sow purple clover among lucerne, for the purpose of procuring an abundant crop in the second year, at which time the lucerne has not yet attained its full growth. For my own part, I have found the produce of lucerne in the second year to be at least equal to that of the clover; and moreover, there is reason to fear that the latter, which at first grows in tufts, would destroy a number of the young lucerne plants. I cannot, therefore, give my approval to this method.

Many persons, on the approach of winter, cover their young lucerne with stiff dung containing straw; I do not deny the possible utility of this method in severe winters, when the ground is not covered with snow. During the winter of 1802-3, the young lucerne plants perished; but we rarely have winters so completely free from snow, or in which the frost penetrates so deeply into the ground, producing not mere cracks, but deep chasms. Moreover, a very thick covering would be required to form a sufficient protection against cold so intense as this. In the winter of 1810-11, when also the ground was not covered with snow, and the cold was very intense, the young

* My experience is not exactly in accordance with that of our author respecting the quantity of seed which should be sown on an acre. I have always found it advantageous to use 16 or 18 lbs. per acre. I admit, however, that when the soil has been turned up to the depth of four or five inches, and properly manured, and the plants consequently grow with extraordinary vigor, it is not necessary to sow so thickly. [*French Trans.*

lucerne plants were not injured. The covering of dung appears to me to render the young plants delicate, to favor the growth of weeds, and the covering of the land with grass, which is very injurious to lucerne, and also to attract mice to the fields. My advice is, therefore, to leave the young lucerne to itself for the first winter.

For the preservation of lucerne it is very important, and indeed almost indispensable, that the ground be strongly harrowed, especially in spring. This operation may also be repeated between two crops, several times in the year, when the grass roots seem inclined to establish themselves in the soil between the lucerne plants. In the spring of the first year, the harrowing must be moderately performed; but in the following year it must be executed with as much force as possible, so as, indeed, to give the land the appearance of a field completely broken up. The harrows used for this purpose must be very strong and well tempered. If there be no large harrows at hand, small ones must be several times passed in all directions. This operation does no harm to a lucerne crop which has already acquired some strength. Such a crop puts forth tufts of greater size and strength in proportion to the depth to which the soil has been broken. An old lucerne field has even been restored to its youthful vigor by having furrows traced on it with the plow at intervals of a foot.

The good effect of spreading dung upon the field is increased by this strong harrowing. Lucerne may be advantageously dunged every two years, in order to maintain it in a state of vigorous growth, but the best method is to manure it alternately with dung and mineral manures. Among the latter, ashes are particularly efficacious; but pounded lime, mixed with mould or turf and pulverized marl, is also very useful. Of all animal manures, the most efficacious is the dung of birds, especially of pigeons, spread very thinly over the land. It is also customary to apply liquid manure, consisting of stable-drainings mixed with water, and allowed to ferment; this kind of manure is used in Switzerland, under the name of *purin*.

Gypsum spread upon lucerne produces as good an effect as it does upon clover.

Lucerne should be mown before the flower-buds show themselves, if we would ensure a prompt and vigorous after-shoot. A well managed lucerne crop may be cut four or five times in the course of a summer.

The strength of each crop increases almost every year, as long as the lucerne field continues thickly covered, and no vacant spaces show themselves, provided always that the harrowing and manuring be not neglected. Even if the old plants do not put forth shoots of equal length with those of the young ones, they have, nevertheless, the advantage in point of thickness: their produce exceeds that of all other fodder-plants. Forty quintals per acre is regarded as an average quantity, but it is said that the produce often amounts to eighty quintals. The richness of the crop depends much upon the quantity of manure that has been bestowed upon it; but temperature has also considerable influence: the hotter the summer the more abundant, generally speaking, is the produce.

Lucerne is either used in the green state to feed cattle, or made into hay; the process of making lucerne-hay is the same as that for clover-hay. In the green state lucerne is most frequently given to horses; these animals gain rather than lose strength when fed upon lucerne, provided they are once a day supplied with a third of their usual feed of oats. Lucerne given to cows seems to increase their milk even more than clover; some persons, however, think that the milk thus produced is thin, and that the butter often acquires a bitter taste. I have not observed this myself.

Lucerne is a very long-lived plant. On a piece of garden ground formerly used as a lucerne field, and afterward turned up twice with the spade and laid down to grass, I have seen isolated lucerne plants grow up which must have been at least thirty years old. A lucerne field may often be kept up for fifteen years; seven or eight years is the time usually reckoned. Some cultivators suffer their lucerne to grow for four or five years only, not so much from fear of its perishing or diminishing, as for the sake of turning the soil to great account by more rapid alternation.

That lucerne may be included in a well arranged field-system, it is necessary that the system contain a great number of divisions, either to allow the lucerne to continue for a sufficient length of time, or because this plant cannot, according to general opinion, be successfully re-sown on the same spot till after an interval of nine years. If the number of divisions be but small, seven for example, it is best to keep a few acres of each for the growth of lucerne; to sow a portion of them with it every year; and after having gone through them all, to break up a portion every year, and devote another part of each division to the culture of lucerne. This method is particularly necessary in places where the fields are not all adapted to the growth of lucerne. In many cases particular spots of ground are devoted to this plant without regular order, being separated for the purpose from the usual rotation.

Seed is not gathered from young lucerne crops, or from such as are to be frequently cut and to last a long time, for the plants are much exhausted by perfecting their seed. I have, however, known them to be completely restored by good manuring. The seed is usually gathered on lucerne fields which are intended to be broken up, the first shoot is mown while young, and the second allowed to ripen.

Lucerne-seed is more easily threshed than clover-seed; but it is less plentiful, and its price is, consequently, higher by one-third.

The breaking up of an old lucerne field does not appear to me to be easy. I have treated such land with three deep plowings, using plows with cutting shares, to prepare it for hoed crops, and, nevertheless, lucerne plants have sprung up again. This, however, is the case with young lucerne only; for the celebrated Pictet de Lancy, who keeps his lucerne growing for four years, only sows wheat after it, as after clover upon a single plowing.

The fertility of a broken lucerne field is very great, especially if it has been often manured during the growth of the lucerne: such land will bear a series of crops without requiring fresh manure.

I must here notice a few particular modes of cultivating lucerne, of which I have treated more at length in the first volume of my "English Agriculture."

By transplantation, wherein the lucerne loses its tap-root, this plant may be cultivated on soils which have but little depth, because it then puts forth lateral roots which require considerable space. This seems to be the principal motive for adopting this method. I have tried it on a small scale, but have found it to be attended with this inconvenience, that the plants which grew very strongly became gradually covered with a woody envelop, hard enough to resist the scythe, and, consequently, grew higher and higher; from this cause the lucerne, after a few years, had to be mown six inches above ground. This method is also very troublesome; the transplanting must be frequently repeated, and three years elapse before the tufts of lucerne unite and press one against the other. Hence, this process has fallen into disuse in England. It may, however, be adapted for the purpose of filling up vacant spaces.

The method of drilling lucerne between grain, and in rows eight or ten inches apart, is regularly increasing in estimation in England, because the culture by which the plant is so much benefited is much more effectually performed with the horse-hoe than with the harrow. I have not yet tried this method.

A well-made lucerne ground, the extent of which is kept up by sowing a new portion every year to supply the place of that which is broken up, gives great assistance to a rural undertaking, and may even fully and safely supply the want of meadow-lands. A meadow never yields on the same extent of surface a produce equal to that of a lucerne field, and can rarely be depended upon with equal security.*

Sainfoin (Hedysarum Onobrychis).

This valuable fodder-plant absolutely requires a soil whose lower stratum contains lime. On such a soil the assistance of a moderate quantity of manure is sufficient to ensure tolerable success to the plant, even on the poorest vegetable stratum; whereas, if lime be wanting in the lower bed, the sainfoin will not thrive, even though the richest vegetable soil should be devoted to it. On such a soil it grows up very well, and appears very thick in the first year; but it afterward disappears without forming tufts. It requires lime or chalk: even if these substances should be in the form of hard rocks, the roots will not fail to make their way through them. Whoever thinks of growing it may save himself a number of costly, and perhaps useless trials, by sounding his land to the depth of four feet.

Land which is to be sown with sainfoin must be cleared of weeds, especially of dog's-tooth grass, which prevents the success of this plant. The clearance may be effected by careful fallowing, or the culture of hoed crops. Sainfoin is greatly improved by recent manuring; but it is often sown on poor soils, and, nevertheless, yields a plentiful crop.

Sainfoin is usually sown with oats or barley; it is, however, sometimes sown in autumn, with corn. The seed is sown either upon or under the lines, but not at any considerable depth. The quantity of seed used is two or three bushels per acre; the latter quantity is to be preferred.

Sainfoin may likewise be advantageously sown in rows with the corn-drill, and cultivated with the horse-hoe, supposing that these implements have been already introduced upon the establishment; this method saves a third of the seed. When we are desirous of growing sainfoin in large quantities, we must endeavor to procure seed from countries in which this cultivation is already established on the large scale; for seed-merchants, who sell it by the pound, charge much too highly for it, and sometimes sell it in an unripe state. But we must make timely application to an enterprising and honest grower; for this grain is not a common object of commerce, and the gathering of it at the proper season requires considerable attention.

As soon as the plants have established their roots in the soil, which sometimes happens in the spring immediately following the sowing, but sometimes not till that of the next year, the sainfoin must be treated, like lucerne, with strong harrowing. If it be manured a little, from time to time, its shoots will be more abundant, and its produce large.

As this plant is usually grown on distant and hilly fields, it is more frequently made into hay than consumed as green-meat. It yields a plentiful crop just as it is beginning to flower, and a second but smaller one at the end of summer; at this time it will also afford very nourishing pasturage. A produce of eighteen or twenty quintals of hay is considered satisfactory; but on a favorable soil, frequently manured on the surface,† the produce may amount to thirty quintals per acre. This fodder is particularly good; many practical cultivators say that its quality surpasses that of clover and lucerne.

Sainfoin is very durable when it meets with a favorable soil, provided that it be properly har-

* All that our learned author has here said on the cultivation of lucerne, seems to me perfectly correct with regard to the north of Germany. But in milder climates, I have had very fine, plentiful, and durable lucerne growing on soils which had not been turned up to a greater depth than sixteen inches, but were in a healthy condition, and gravelly. I have even obtained from such lucerne grounds as much as eighty quintals of dry fodder per acre, *during the years of their greatest vigor*; and I have scarcely fallen short of this quantity on rich lands which had been cultivated to the depth of the spade only; that is to say, about twelve or thirteen inches Rhine measure.

Lucerne fields give more frequent and plentiful crops when they are watered in time of drouth with warm or calcareous waters, by irrigation, or momentary inundation; but generally speaking, their duration is shortened by this treatment, because the soil acquires an increased disposition to become covered with grass. Count Ph. Ré, formerly professor of Agronomy in the University of Bologna, and now at Modena, has gone through a series of conclusive experiments on this point, in the agricultural garden of the first mentioned University. In all cases it is of the utmost importance to take proper precautions to prevent the lucerne roots from coming in contact with stagnant and subterranean waters; but this precaution becomes doubly necessary when the lucerne field is to be watered. [*French Trans.*

† On the borders of the Lake of Geneva, where sainfoin is much esteemed, especially for feeding horses, it is often supplied with mineral manures, especially gypsum; but an opinion is entertained (and I think that I have had practical demonstration of its correctness) that animal manures cause the plant to make an effort of vegetation which hastens its death. [*French Trans.*

rowed and manured, especially with ashes or gypsum, and not too often required to produce seed. Fields of sainfoin have been kept in excellent condition for twenty years.

Sainfoin sometimes penetrates the ground twelve inches deep; plants of it have even been found whose roots went to the depth of sixteen inches. The roots are very strong in the upper part, so that it is not easy to break up an old sainfoin layer: this labor is, however, willingly undertaken, because a field of this description, which has previously not even repaid the expense of sowing, will afterward yield several fine crops without fresh manuring. The light vegetable stratum, covering a calcareous rock, is thereby considerably increased, and the vigorous roots of the sainfoin appear to lighten the rock and divide the calcareous stones. It seems, however, to be matter of observation that sainfoin will not, till after a very long interval, thrive on land which it has previously occupied.

This plant, which seems to penetrate the depths of the soil to seek nourishment which it afterward yields to the surface, is, for many countries, an invaluable gift of Nature; while, in others, it is absolutely unavailable. Excellent fodder may, by its means, be obtained on the tops of the most barren hills, sufficient, indeed, to supply the want of low meadows. The latter may then be sometimes advantageously broken up, and thus the usual order of Nature, which seems to design the valleys for producing fodder and the hights for cultivating grain, may be inverted: but we must be careful to ascertain *quid quæque ferot regio, quid ferre recuset.*

VARIOUS OTHER FODDER-PLANTS, WITH PAPILIONACEOUS FLOWERS.

Attempts have been made to cultivate various other plants of the genus *medicago*, and others bearing some affinity to them, and several authors have recommended these plants; but their cultivation has nowhere been continued, or even generally adopted. The cause of this neglect is not so much that the plants thus recommended have been found unfit for the uses to which they were destined, as that they are, in many respects, inferior to those already spoken of; and that where the latter have been found unavailable, the former have likewise yielded but an indifferent return. Of this number are the following:—

Yellow Sickle Medick (Medicago falcata)

Which grows wild almost everywhere, and thrives on bad soils: its produce is, however, but small; and, on good land, it is far inferior to lucerne.

Black Medick or nonsuch (Medicago lupulina)

Is liable to the same objections, as are also various kinds of *Lotus*; for example, *lotus siliquosus* and *lotus corniculatus*, or common bird's-foot trefoil; various species of *Lathyrus*, viz., *lathyrus pratensis* or meadow vetchling, *lathyrus sativus*, and *lathyrus tuberosus*; several species of *Orobus*, such as *orobus niger* or black bitter vetch, *orobus sylvaticus* or wood bitter vetch, and *orobus lutæus*; also, *astragalus cicer*, and various kinds of wild vetches.

All these plants are excellent in natural meadows, where they grow among the rest of the herbage. When meadows are to be sown with them, it is certainly advisable to procure the seed from other meadows in which they grow abundantly, and for this purpose to allow some portion of the plants growing in the latter to perfect their seed; but if I may rely on my own experience, these plants do not yield a satisfactory produce when separately cultivated.

Plants have also been recommended which appear very desirable on account of their strength of vegetation and the long time for which they last; but it appears to me that cattle accustomed to better nourishment, absolutely reject them. Among this number is the *galega officinalis*. Particular attention has been directed to the discovery of a plant which shall thrive on poor and sandy soils, enable them to yield a moderate return, and at the same time improve them. According to the English, French, and Belgians, these qualities are possessed by the common furze, *(ulex Europæus)*. At all events, this plant is the one generally alluded to by agricultural writers who speak of furze. It grows likewise in the north of Germany, but not spontaneously; and I am not acquainted with any trial that has been made of it in our part of the country. We have, however, a very similar plant, which grows abundantly on the worst lands, viz., the common broom *(spartium scaparium)*. It appears to me, indeed, very probable that this, and not the common furze, is the plant really spoken of in the works of foreign authors. Several persons have proved that broom, when properly prepared, is eaten by cattle quite as readily as furze. For an account of the excellent effects which the culture of this plant produces on sandy and heath-lands, I refer to the dissertation of Francis de Caster, in the third volume of Schwertz's "Flemish Agriculture," and various other passages of the same work; also to Arthur Young's "Tour in France," particularly the third volume. The seed of broom is sown, like that of other fodder-plants, among the spring or autumn grain, and the soil is devoted to the plant for five or six years. When the broom has been cut, it is given to the cattle; the most delicate leaves are given to sheep, and the harder stalks used as manure: where fuel is scarce, these stalks are dried and used for burning. But if it be desired to make these harder stalks also fit to be eaten by cattle, they may be bruised with an instrument resembling a braque, or, what is still better, they may be reduced to a semi-fluid consistence by the bark-mill, and given to the cattle in that state. The fodder thus obtained is said to be of the most nourishing description, and to impart a most agreeable flavor even to winter butter. I have never myself tried this use of the broom; but I would recommend the trial to those who often find this plant growing wild, especially on the borders of fir woods. The use of broom is recommended by many considerations.

Corn Spurry (Spergula Arvensis).

This plant is essentially different from the wild spurry *(spergula pentandra)*, both in nature and habits, but I am not aware of any characteristic mark by which the two may be distinguished; for the occurrence of ten stamens on the former and five on the latter is by no means constant, flowers with five and with ten stamens being often found in the same plant. The two species

are, indeed, scarcely distinguishable excepting by their stature and time of flowering. Some persons are afraid that the cultivated species may degenerate into a weed, and, at last, multiply spontaneously; but I have doubts on this point. I have, indeed, often remarked that when spurry ripens upon a field, it shows itself in the following year among the plants sown either upon this field or the adjoining ones. This growth arises from seed which, having been shed and dispersed by the wind, remains dormant during winter, and shoots forth in spring; but after a year or two, it disappears entirely, for the young plants are incapable of withstanding frost, whereas the wild spurry is not injured by it.

There are two varieties of cultivated spurry: the one rises to a small hight, but grows thickly; the other attains double the hight of this one, but never grows thickly or surpasses it in produce, excepting when grown on a very vigorous soil. The former is proper for the poorer soils, on which alone spurry is usually sown; it is also better adapted for a pasture plant. The latter variety is the more advantageous for sowing on very fertile land, with the intention of mowing it. The two varieties may be distinguished by their seed: the smaller has a black seed marked with a white ring; the larger, a brownish seed, which, when closely examined, appears spotted with yellow and dark brown, and is usually without the ring.

By mixing the two seeds, I have obtained a medium variety, which grows to a much greater hight than the small kind, and, at the same time, very thickly. I have obtained excellent crops from this variety even on middling soils, and fit for either pasturage or mowing.

Spurry grows on almost all soils, even on the very bad sands, provided there be no want of water during the time of its growth: but its strength and produce vary almost infinitely, according to the quantity of nourishment contained in the soil on which it grows. It is rarely cultivated on fertile soils, but its produce is not equal to that of clover. On the other hand, it presents the great advantage of not occupying the ground long, for it may often be mown eight weeks after seed-time, unless its germination has been retarded by excessive drouth. There are, therefore, cases in which spurry may be advantageously cultivated on the best lands: many cultivators may have recourse to it, when their clover fails.

Another great advantage afforded by spurry is, that it produces plenty of seed, which is easily gathered and threshed, and therefore very cheap. When the necessary quantity is grown on the land, it may be set down at a very low price. In calculating the expense, however, we must not altogether lose sight of the fact, that spurry, when allowed to ripen, and particularly when pulled up, exhausts the soil to a great degree; whereas, that which is mown or fed off while young, affords a very sensible increase of nutriment.

Five pounds of seed are required for an acre; but if the soil has been well prepared, and the seed be scattered with perfect uniformity, this quantity may be diminished.

The soil does not require extraordinary preparation, unless, indeed, it is infested with dog's-tooth grass. Even if this be the case, the spurry will still grow up, but the dog's-tooth grass will soon choke it. Spurry may be sown from the middle of May to the middle of August. In dry weather, the seed should be sown immediately after plowing, the soil having been perfectly leveled with the harrow. The success of the crop depends altogether on the circumstance of the spurry meeting with a well-pulverized layer of earth at the surface. Hence it is better to follow the harrow by the roller, and then to harrow again—afterward to sow the seed, and finish by once more passing the roller over it. The spurry then rises quickly and equally, a point of great importance.

Spurry is usually sown by itself; I have, however, seen it mixed with clover, the young plants of which were very advantageously protected and sheltered by the rapid growth of the spurry; and, after the latter had been mown, shot up vigorously and very close together. Spurry has also been sown with buckwheat intended for mowing as a green-crop. It might, perhaps, be economical in some cases to sow spurry among grain which grows up into the ear, for the sake of obtaining good pasturage on the stubble. It is often sown on the broken corn stubble, to obtain autumnal pasturage, or green-meat. At this season it is scarcely, if at all, injured by slight frosts.

Spurry is mown while in full flower, either to be consumed as green-meat, or made into dry fodder. Its lower flowers, however, often begin to expand very early, and it is just at this time that the plant begins to vegetate most strongly; we must not, therefore, be guided by these first flowers, when we intend to take but one cutting. If spurry be mown while very young, it will shoot up again, and a second crop may be obtained from it, often more considerable than the first. But the first crop is scarcely worth the trouble which it occasions; it is, therefore, better in most cases to have it fed off on the ground—but quickly, and by a considerable number of cattle. The spurry will then not be injured by this pasturage, but will afterward shoot up with greater strength and thickness.

The produce of spurry is, as may be conceived, subject to endless variations, not only according to the nature of the soil, but also to the state of the weather; for this plant requires heat and frequent showers. It stops growing in unfavorable weather, but quickly recovers itself when the weather again becomes congenial to it. The quantity of its produce may be estimated at the half of a crop of clover raised on the same extent of surface. When spurry is laid up in heaps, it becomes much compressed, and undergoes considerable diminution of volume; but, at the same time, it increases in density, and a given weight of it is then much more nourishing than the same weight of any other kind of fodder, as those who cultivate it soon find out. When cattle are fed on spurry, either green or dry, the increase of their milk and fat is sensible to the eye. Spurry is likewise one of the best kinds of fodder for producing butter and milk of agreeable flavor.

Spurry is easily convertible into hay by making it up into small cocks as soon as it is partially dried. When the weather is fine, the plant will dry completely of itself: but in wet weather the cocks must be now and then stirred and turned over. Spurry may be exposed to rain for a long time without spoiling or losing its nutritive qualities. The earlier it is mown, the more nutritious is the fodder which it yields: but even the straw—that is to say, the haulm of spurry which has

run to seed—appears to me to be more nourishing than any other kind of hay. It is still green when mown; for we cannot venture to let it ripen very far, for fear that it should drop its seed.

The seed may be turned to very good account, when the quantity gathered is larger than we want. Oil may be expressed from it, though not in sufficient quantity to be profitable: it is thought better to use this seed for feeding live-stock: its nutritive power has been shown to be very great. Spurry-seed, when used for this purpose, is steeped in warm water: it then loses its germinating power, swells, and becomes digestible. If not treated in this manner, it passes through the bodies of animals unchanged, and with its germinating power undiminished. When prepared as above, it is given to the cattle, either in the form of wash, or poured upon chopped straw. In cows that are fed upon it the increase of milk is visible; and it is said that the milk and butter thus produced do not acquire the unpleasant flavor which is perceptible when the animals are fed upon other oily substances. Schwertz informs us that this practice is universally adopted in Belgium.

Various other fodder-plants, such as *pimpernel chiccory*, and several kinds of grasses, are best adapted for pasture-grounds.

There remain, however,

The tall-growing Grasses,

which are cultivated in the fields for mowing.

These grasses may be called *Hay*, or *Stalk-grasses* in contra-distinction to *Pasture* or *Leaf-grasses*, because the former have vigorous stems with strong leaves attached to them; whereas, those of the second class bear feeble and leafless stems, but have strong radical leaves, which grow with greater vigor the more they are fed off, and kept short by the teeth of animals.

Ray-grass (Lolium perenne).

Of all cultivated grasses this is the most celebrated, and the one which has most steadily maintained its reputation. Two essential qualities are united in it: first, it may be mown; and, secondly, when fed off, it forms a close sward, which grows again with great vigor. It thrives on stiff, and also on sandy clays, provided they are not in very dry situations. It gives but one crop per annum, for mowing; but the fodder which it yields is very substantial when it is cut before flowering: after that, its stems become hard. The English usually sow it among purple clover, and never neglect it when the clover is intended to stand for a number of years, because the ray-grass multiplies as the clover thins. The chief advantage of this grass consists in the facility with which its seed is gathered, and the quantity which it yields. The part from which the grain is to be collected is allowed to ripen; it is then mown, and the grass is treated like corn, and threshed in a similar manner: 20 scheffels may be obtained from an acre: the quantity of seed put upon this surface is about 1 scheffel, or 1¼ scheffel. The residue of the threshing can only be looked upon as straw: but the plant shoots up again in autumn, and the exhaustion consequent upon the ripening of the seed may be repaired by manuring. In England, the most varied trials have been made with an immense number of grasses, and the result has been that the cultivation of ray-grass in the field has been continued, or, at all events, resumed.*

Common oat-like Grass (Avena elatior).

The plant so called by the French was at first confounded in France with the ray-grass of the English; but it is altogether different—its stems or reeds are much longer, and more thickly covered with leaves, and it does not form a close sward. Like the former, it grows on soils of all kinds, provided they are in a state of fertility. and yields as its first crop a greater quantity of hay than ray-grass: it afterward yields a second, but weaker crop. It lasts till the fourth or fifth year, especially if it be supplied with manure.

But its cultivation is incomparably more troublesome and costly than that of ray-grass, because the unequal ripening of its seed causes great difficulty in taking the crop. It begins to ripen on the top of the panicle, and falls as soon as it is ripe; so that we cannot collect all the seed from a stem, unless we take some of it in an unripe state. There is yet greater irregularity in the ripening of the stems, so that they must be gathered almost one by one, and dried in a barn where they will be well exposed to the air. The difficulty of taking the crop is a great obstacle to the extended culture of this grass. It often happens that, of a quantity of seed purchased of a seedsman, not more than a fourth is ripe: and hence it becomes impossible to obtain a thick herbage, even by sowing several scheffels on an acre of ground.

Especial care must be taken to avoid confounding this grass with the *avena bulbosa*, and not to take the seed of the one for that of the other. They are much alike; but the latter species is a very troublesome weed, which continually multiplies by its bulbs.†

Tall Fescue-Grass (Festuca elatior).

This grass is very similar to the preceding in its economic characters, but it requires a more humid soil; when it meets with such a soil, it yields a larger produce than common oat-like grass.

Its seed does not shed so easily as that of the latter; it must, however, be carefully gathered, and from each stem separately.

* The Italians, particularly the inhabitants of Lombardy, who, as well as the English, often associate ray-grass, which they call *lojezza*, with common purple clover, think that it affords, among other advantages, that of preventing distention of the stomach in ruminating animals, an accident which the carelessness of servants often brings upon cattle fed upon pure, tender clover In Italy, too, this plant often yields two or three crops in a year; and I have seen upon my own land, even in a season of extreme drouth, a very good second crop of lojezza taken, with its seed perfectly ripe. [*French Trans.*

† By its bulbs, and also by the numerous lateral shoots proceeding from its stem and between the bulbs, which shoots soon give birth to others; and lastly, by its seed, which ripens easily, and in considerable quantities among corn. It is, undoubtedly, one of the most detestable weeds with which a soil can be infested. [*French Trans.*

Cock's-foot Grass (*Dactylis glomerata*).

This plant is cultivated and used in the same manner as common oat-like grass. It must be mown very young, when it is beginning to put forth its stems, for it is only in this state that it is agreeable to cattle. As soon as its panicles are formed, the stems become hard. Moreover, if mown early, it will yield a second crop, which would otherwise be quite insignificant. The grain adheres firmly to the ear, and admits of being cut with the scythe. It is usually found among the seed of common oat-like grass purchased of seedsmen. Seed thus obtained often yields a larger quantity of cock's-foot than of oat-like grass.

Dog's-tail Grass (*Cynosurus cristatus*).

This is in all respects similar to the preceding, but is more inclined to harden. Both species thrive equally well on a dry but rich soil.

Common Cat's-Tail or Timothy Grass (*Phleum Pratense*).

This grass requires a moist situation on a light soil. When mown young it is soft and grateful to cattle; but after it has formed its ear, it becomes hard, and the hay is no longer good, excepting for horses. As it shoots late, it yields but one crop.

Cat's-tail grass produces a large quantity of seed, which does not easily shed, so that it may be mown and threshed. This seed is very small, a few pounds only being required for an acre. It is probably from this circumstance that the culture of Timothy grass has become more extended than that of any other.

The seed of this grass was first imported into Germany from England, and into England from America. The plant, however, grows wild in our country; but that imported from America appears to me to be a particular variety, for the thickest and most vigorous crop of Timothy grass that I ever saw was that of a field for which the seed had been imported from England. This was thirty years ago, and at that time the English imported this grass from America.

Woolly Soft Grass (*Holcus lanatus*)

Has been particularly recommended by many writers on Agriculture. In my opinion, however, it is one of the worst and least agreeable to cattle of all grasses. At all events, it must be mown very young. It yields but one crop; but toward autumn it shoots up again strongly, and in tufts, so that it then furnishes a tolerably abundant pasturage, even on sandy and elevated soils, where, indeed, it is eaten by cattle, for want of better nourishment. This grass is often destroyed by frost in winter, when it grows alone, instead of being mixed in the sward with other grasses.

The seed may be collected by mowing and threshing, but it is very difficult to get the grain out of the husk, and therefore the husk is often sown with it. In purchasing it we must be careful to notice whether the grain is separated or still in the husk: in the latter case several scheffels per acre will be required, in the former a pound will suffice, provided the seed be ripe and carefully spread.

Meadow Fox-Tail Grass (*Alopecurus Pratensis*).

On a rich and moderately humid soil, whether consisting of sand or clay, this grass is, perhaps, the best that can be cultivated in our climate. It puts forth very thick and vigorous leaves, both from its stalk and its stems; it covers the soil well, shoots forth early, and grows again very quickly, so that three crops may easily be obtained from it in the course of a year. When mown young, at the time when the ears begin to show, it is very grateful to cattle. It is not at all adapted to dry and meager soils.

The seed should be gathered by plucking. When the grass is ripe, the ear must be taken hold of, and drawn toward the gatherer in such a manner that the husk, in passing through his hand, may separate from the grain and leave it behind. This grain must then be immediately spread out in a well-aired barn, as it will otherwise become heated, and lose its germinating power.

Meadow-Grasses (*Poa*).

Smooth-stalked meadow-grass (*Poa pratensis*); roughish meadow-grass (*Poa trivialis*), and various other species of *Poa*, afford the best of all kinds of hay: meadows on which they grow are preferable to all others. But these grasses are not fit for separate cultivation, on account of the difficulty of gathering their seed and separating it from the woolly covering which keeps it united in knots, and absolutely prevents the uniform spreading of it. The *Poa* grasses, to thrive well, require a rich meadow soil.

The culture of grasses intended for mowing may be useful in certain cases; for example, when we wish to procure a fodder-field that may last for several years, and the soil is not adapted to the cultivation of lucerne, particularly if it be too damp. But this branch of husbandry can never be much extended, both on account of the difficulty of gathering the seed, and also because clover yields a larger produce, allows of alternation with the culture of grain, and prepares the soil for that cultivation. The culture of grasses should be reserved for the light, black soil of low countries, where clover often fails, and which are especially adapted to this description of plants. But soils of this nature have usually considerable inclination for the growth of herbage, and the seed of grasses that are proper for them is usually multiplied upon them to such an extent that artificial sowing is scarcely necessary. The gathering of the seed, or the very high price which it costs, and the difficulty of spreading seed of such extreme lightness in a uniform manner, are insuperable obstacles against any great extension of the culture of grasses for mowing.

We have already spoken, in the proper place, of the use of vetches, rape, colza, buckwheat, maize, and various mixtures, both as green food for cattle, and for hay-making.

SECTION VI.

THE ECONOMY OF LIVE STOCK.

Under the denomination, "*economy of live stock*," we include not only the breeding and rearing of animals, but generally all that relates to their maintenance, even when not connected with breeding.

We have before spoken of the necessary relations between the economy of live stock and Agriculture, and the proportion which must be maintained between them. It is rare to meet with cases in which these proportions are less important; in which, for example, the necessary quantity of manure can be purchased, or cattle belonging to other parties can be taken into the establishment, either for a fixed rent, or by giving up a certain quantity of fodder to the owner of the cattle, on condition of its being consumed on the establishment itself by a certain number of cattle, and under the inspection of the proprietor. The latter method is highly convenient for the cultivator, and is adopted in many counties of England, where cattle from Scotland are fattened on the farms. It is likewise common in Switzerland, where the milch cows are taken in autumn from the Alpine pastures to winter in the plains. In other countries this system is rarely pursued.

The much-disputed question as to whether the culture of grain or the economy of live stock yields the greater profit, or which of the two it is advisable to follow in preference to the other, cannot be decided on general principles. The pecuniary profit derived from the management of live-stock increases or diminishes with the welfare of civilized nations, because the consumption of animal food becomes larger in proportion to the well-being of the community. A large exportation of a particular kind of animal produce, in consequence of its recognized quality, may, however, cause a rise in its price; this is the case with Holstein butter and Swiss cheese. Sometimes one portion of the live stock, the value of which in other places is but small, will yield so high a profit that the price of the rest will fall proportionably low. Such, for instance, is the case in this country with sheep, which, on account of the high price of their fleeces, have been multiplied to such an extent that the market is overstocked with mutton; whereas, in England sheep are kept principally for the sake of their flesh.

In our circumstances the economy of live stock rarely yields a large profit, if we charge it with manure and pasturage at the market price. But we are usually satisfied when the expense of these matters is properly repaid by the maintenance of cattle, and our straw is converted by their excrements into an active manure. A large number of cattle maintained in this manner with great care and at considerable expense always yields an adequate return; and, generally speaking, it is observed in almost all countries that rural undertakings which maintain large numbers of cattle, and feed them well, are, in the end, more profitable than than those which have only the number absolutely required, and feed them but scantily.

The advantage of one or other kind of live-stock depends partly on circumstances of place and time, and partly on the skill and industry with which they are treated. In general, we may lay down as a rule for our country, that horned-cattle are most profitable on low pastures, and when maintained by stall-feeding; sheep, on the contrary, on all dry and elevated pasture-grounds, natural or artificial.

HORNED-CATTLE.

It is not yet decided whether our domestic ox is descended from the same stock as the wild bull and buffalo. But as these animals not only breed together, but also produce a race which is capable of perpetuating itself, it is probable that our domestic cattle are descended from the wild race, and owe their change of form entirely to the kind of nourishment and the care which man has bestowed upon them.

But even among our own horned cattle we may observe a great diversity of races, which is transmitted from generation to generation. These changes may have been brought about by climate and mode of living; but if so, the effect must have been produced by very slow degrees, for we do not find that either of these circumstances has any prompt and marked influence on a race which is maintained in perfect purity. The choice of individuals for propagation has, in all probability, contributed most powerfully to the perpetuation of constant and distinct races, and particular varieties have been subsequently produced by crossing.

In Germany, (under which title I include all the various empires and provinces in which the German, with its several dialects, constitutes the prevailing language) the races have lately been mingled in so many ways, and with so little definite purpose, that their distinguishing characteristics can no longer be recognized. We must, however, distinguish the three following races:—

(a). The low-country race.
(b). The ordinary race of the high grounds.
(c). The mountain race.

But these races, which are in themselves sufficiently distinct, have often been mingled.

The *low-country race*—whose distinguishing marks are a fine skin and hair, large size of body, strong bones, and short horns—is met with in several countries under different names. But it includes many varieties, each of which is distinguished by some peculiarity, especially in countries where constant attention has been paid to breeding and choice of individuals. This race probably derives its origin from the first cultivated countries of the Lower Rhine, the Elbe, the Weser, and

the coast of the Baltic. It is probable that the Flemings—who, being a peaceful and industrious people, multiplied quickly, and established themselves in other low countries, in which they were readily employed to cultivate the land—introduced the race into these countries, keeping it pure in some cases, and mixing it in others to a greater or less extent with the native breed of the country. The low-country breed is known in these parts by the name of the Friesland breed; it is likewise often called the Oldenburg or the Bremen breed, because it was brought to us by cattle-dealesr of those countries in which it has partly been raised. The race found in the rich valleys of Holstein and Sleswick is in in some respects different from the former. This is still farther true with regard to the breed which has been formed in the low countries around Dantzig and Tilsitt; these races, however, resemble one another very closely. In England the same breed is known by the name of the *short-horned* or *Holderness breed*, and is thought to have been originally introduced from the Netherlands. Contrary to the opinion which has hitherto been common, I think that we ought to include in the same race the *large Swiss breeds*, of which such excellent portraits are given in the second part of the "*Deutschlands rind Viehracen*," by M. Witte, viz., the *Friburg* race, and even the smaller *Simmenthal* breed, which certainly does not belong to the primitive mountain races, although it thrives on the rich pastures at the foot of the Alps, at the same time that it is very well adapted for stall-feeding. This race has been again transplanted into some of the more fertile countries of Southern Germany and Franconia, particularly the Margravate of Anspach.

These several races are all esteemed as milch cows, because, when properly fed, they give more milk than any others. But they are delicate, and require food not only in abundance, but also of particularly good quality: when badly fed, they soon degenerate, their produce diminishes, and afte a short time they yield no return whatever.

The crossing of this large breed with others is not always successful, especially for the first few generations. But when the breeding is judiciously managed, the animals which are coupled not being too dissimilar, a breed may be obtained far superior to the primitive race for certain localities, and possessing its good qualities without its defects. When such a race has been obtained, it must be perfected by itself.

This race of cattle does not appear to be well adapted for draught; for, though very strong and healthy, they are not sufficiently robust and hardy for that employment; besides, their maintenance is too expensive. It is only by crossing and after a lapse of years, that strong and robust beasts of draught can be obtained from this race.

Great weight and *embonpoint* may be given to these animals by fattening: but for this purpose a large quantity of very nourishing fodder must be used; and when a beast of this description is lean, an enormous supply of food is required to fatten it again.

The native races present great diversity both on the low grounds, and on the hills. Our German breed, originally of a reddish-brown color, and with large horns, has retained more or less of its size and vigor, according to the manner in which it has been treated. This race is found in its best and purest state in Vogtland: but in most places, it has greatly degenerated, for want of sufficient pasturage, and from over parsimonious treatment. It might, however, be again improved within itself, by means of better nourishment, more careful treatment, and a proper choice of individuals for breeding.

It never yields so much milk as the low country breeds: the milk is, however, on the average, of richer quality; and, in proportion to the quantity of food consumed, often yields an equivalent net return.

The hardihood of this race renders them well adapted for draught. In many countries, particular attention is paid to the rearing of oxen from it: very large and strong animals are thus obtained, which scarcely seem to spring from the same origin as the cows of this breed; which are, for the most part, very small and stunted.

In other countries the native race is strongly marked. A breed of great interest for northern Germany is that of *Jutland*, which is excellent both for milking and fattening. The hair of this breed is peculiar, of a dun or tawny color, often spotted with white: individuals are, however, found, having black or gray hair; but a reddish-brown color is very uncommon among them; and wherever I have met with it, the form of the animal has appeared to me to betray a different origin. The bones are small, the legs short, the body long and deep, the fore-quarters proportionally weaker, the hinder large and strong. The physiognomy is peculiar: jaws thin, mouth elongated and pointed, head and neck thin. There is a feminine appearance in all these animals, even among the males, and this character would be yet more widely diffused, were it not that the bulls are usually chosen for breeding from another race, in which the bones are larger and the head thicker.—The Jutland breed is lively and robust, and preserves its milk and flesh better than the other cattle of the country, on bad and scanty pasturage.

This race is much esteemed for fattening, because the muscular fibre is delicate and savory; and the bones and offal weigh but little in comparison with the useful parts. The animals also readily increase in muscle and fat; though the latter substance is not developed externally so much as between the flesh and muscular fibre, where the lean and fat are so agreeably mixed. Where this meat is known. it readily fetches a somewhat higher price than other kinds. The cows, which are very lean when they begin to give milk, increase in fat when well fed, in proportion as their milk decreases; so that, at the end of their milking time, they are fat enough for killing.

As we usually obtain them, the cattle of this race are smaller than those of our ordinary German breed, either on account of the scanty nourishment which they find in their own country, or because they are paired too early. I have seen heifers brought from that country before they have borne young; and such as happened to be in a situation where they were well fed, attained great length, though they did not grow very tall. But the progeny of this race, when supplied with plenty of nourishment, may become very large: a cow of this breed, which was killed as soon as milk was no longer taken from her, yielded 550 lbs. of butchers' meat, exclusive of offal. In their own country, animals of this breed are met with which attain a remarkable length, without, how-

ever, growing tall, and give an astonishing quantity of milk: but they are not in the market. There is, perhaps, no other race which, under ordinary circumstances, is so well deserving of careful endeavors to perfect it.

Among the mountain races, that of the *Swiss Alps*, or the *Hasli* breed, is the most remarkable. M. Witte has given us an excellent drawing of it in the work already spoken of. It is indigenous in high mountain regions only; but has been naturalized in other situations, and even in Lower Saxony, originally in the countries of the Hartz. I will not, however, take upon me to decide whether the race thus transplanted may not be the less perfect breed of Schwytz, a drawing of which is to be given in the work of Witte. The Hasli race is small, but elegant and well built.—The horns have a peculiar curvature directed backward, and become very thin toward their extremities. The head is narrow, but the mouth large in proportion to it; the ears spring from thick tufts of hair; the neck is short; the legs, especially in the fore-arm, short and very thin, but furnished with very strong nerves and muscles; the foot is small and perfectly well shaped; the tail long, reaching almost to the feet, but thin, and terminated with a large tuft of hair. The body is long in proportion to the general structure, and of a fine blackish-brown color, deepest toward the lower parts. A tawny streak, inclining more or less to whiteness, extends along the neck and back to the middle of the tail. The ears, mouth, and legs, are usually of the same color. The eye is commonly surrounded by a tawny ring: the udder of the cow is of the same color, and covered with hair. Sometimes the animal is also marked with white spots.

This race exhibits very little disposition to fatten; perhaps on account of the free and, in some respects, fatiguing life which the animals lead on the Alps. I have, however, seen their descendants become tolerably fat when stalled.

Cows of this breed give very good and rich milk, in proportion to their size, and the kind of pastures on which they graze: even on the Alps, however, there is a great difference between one individual and another. In our own country I have seen descendants of the race sometimes highly valuable, sometimes altogether valueless, for their quantity of milk. But I have always seen them larger here than M. Witte describes them on the Alps.

The *Tyrolese* cattle approach in some measure to the latter as regards their stature; but on the average they are much larger, and of a red-brown color. The abundance of their milk is much vaunted, and has often led to their introduction into low countries, where they thrive very well, even when stalled. Notwithstanding the expense of transporting them, they have lately been brought into our part of the country.

The *Styrian* race, at least that which is known to me by this name, is similar in form and color to that of Hasli; but it is larger. Its color is lighter, and the spine curved to an extraordinary degree, both in the cows and the bulls; which, moreover, are exceedingly beautiful. I must, however, confess my inability to give an exact account of the peculiarities of this breed, having seen but a small number of individuals belonging to it.

In this country we often meet with *Podolian* oxen, upon whose origin I have not yet been able to obtain exact information. They are almost all of a fine gray color; sometimes, though rarely, black and spotted with white. They are high on their legs, and not very long; but their breadth is considerable, especially behind in the croup. It is said that this race cannot be used as milch cows, because they will not allow themselves to be milked; but the oxen are particularly well adapted for fattening. When they are brought to us in autumn, they will have already fattened considerably on the rich pastures of Ukraine; and, in spite of the long journey which they have performed, some of them will be sure to be fat enough for killing. Others will have grown thin; but they will soon recover their fat when stalled or fed upon potatoes or hay. In this manner they may be completely fattened in ten or twelve weeks, and their weight increased to 800 lbs.

The *Hungarian* cattle resemble the latter in color, but are longer, and have shorter legs. Podolian oxen may be used for draught: they are usually very docile, but some of them are very vicious and cannot be broken in: moreover, they do not appear to be very robust. The Hungarian oxen appear to be better adapted for work, and more vigorous.

By the choice of individuals of a particular race, or the crossing of different races of horned-cattle, families are formed, possessing characteristics of a greater or less value, which, when they answer our purpose, we must endeavor to perpetuate among the families themselves. When these characters become constant, the family may be regarded as forming a distinct race. The crossing must, however, be conducted with care and circumspection. Since the greater number of cattle are reared for the sake of obtaining milk, the chief desideratum is a family of good milkers; and from this family, when obtained, we must endeavor to raise a distinct breed by always selecting the best individuals to form the nucleus of the race, and taking from among them the male and female calves to be used in perpetuating the breed. With regard to the males, most breeders are too much guided by a certain conventional beauty of form, which in many cases is not really the most desirable characteristic. When a constant race is to be formed, we must begin by coupling animals of the nearest parentage, provided they are free from defects, and adapted to the end proposed. I am now engaged in forming a breed by the crossing of the Friesland, Swiss, and Jutland races.

Breeding of Cattle.

Great care must be bestowed on the choice of the bull. With respect to form, the characteristics usually required in a bull are, that the head be short and thick; forehead broad and wrinkled; eyes black, and lively; horns short, and dark colored; ears long, and well placed; nostrils large; mouth black; neck short, and fleshy; chest broad, and expanding beyond the legs in front: body elongated; legs short, and shaped like columns; tail long, and well covered with hair: he should likewise have a bold and lively gait. A broad front is much valued by some persons: for my own part I prefer that the animal's hind quarters should be in good proportion to the front. First, that when he leaps the cow, he may be able to keep himself up without pressing too heavily upon her; and, secondly, because a strong croup appears to favor a large secretion of milk. I likewise

prefer a bull with a long and fine head, and a thin tail: but my chief care is to select one that is the offspring of a good milch cow.

Many persons endeavor to rear bulls of great stature, by giving them a very plentiful supply of food. I am, however, of opinion that bulls may be of too great stature, so that it may be necessary to leave off using them at the very time when they attain their greatest strength, because they then become too heavy for the cows. They are often allowed to leap before they have completed their second year. This has the effect of reducing their size; but it also weakens their constitution to such a degree that they lose their generative power by the time when they have attained their sixth year, the very age at which they would otherwise be just arriving at their full vigor.

The following marks and properties are regarded as characteristic of a good breeding cow, and as justifying the expection of a goodly supply of milk. The body and frame should not possess much beauty of form: the latter descending from the spine, should grow larger toward the lower part, so as to form a large and pendulous abdomen. The general contour of the body should be rather egg-shaped than round; the rump as broad as possible, and the front narrow in proportion to it. The bones, especially those of the legs and head, should be thin: a thin tail is also a good mark. The physiognomy should be feminine—mild, but lively. The animal should be cheerful and good tempered, but bold. The udder should hang down behind between the legs; it should be large, not fleshy, but thin and soft, displaying large milk veins. A considerable hollow under the belly, deep enough to thrust the thumb into, is by many persons regarded as a sign of a good milch cow; but in my opinion this character is more deceptive than any other. A long, thin tail, reaching almost to the ground is likewise regarded as a good sign. But it is of primary importance that the cow be descended from a mother which was a good milker, healthy, and of a good stock. I have seen many good milch cows whose legs were very close together near the hams, although as beauty is concerned, this conformation is not approved. Some persons require that the hinder extremity of the thigh should form a right angle with the hip bone, which projects near the tail. Moreover, the thigh should not be thick.

If we wish to produce cattle of large size, we must choose cows of considerable stature, and full grown, for thickness and length of body are inherited more surely from the mother than the father. I am therefore decidedly of the same opinion as the Swiss, who endeavor to keep their bulls small so that, in fact, the bull is often the smallest animal of the whole herd.

One bull might serve for seventy or eighty cows, if the seasons of the latter were equally distributed throughout the year; but as that is not the case, we must not reckon more than twenty-five, thirty, or forty cows to each bull, accordingly as the former require at one particular time of the year, or at different seasons. Besides, a bull might be attacked with illness that would render him unfit for leaping, and great embarrassment might thence result. It is therefore usual to keep two bulls for forty cows—a young one, in his third year, and an older one, in his fifth or sixth, so that the younger and weaker cows may be covered by the former: the older bull would be too heavy for them.

When it is our object to increase the size of a breed of cattle, we ought undoubtedly to let the heifers attain the age of three years before they breed; this is indeed always necessary when the young cattle have but scanty and inferior pasturage, and we wish to preserve the breed from degeneracy. But if the young cattle have been well fed and nurtured from their birth, we may without hesitation allow them to breed when they are nearly two years old: and I think it right to do so whenever the young heifers come to early maturity, for they will otherwise either become lean and stop growing, or, if they are still well fed, they will grow fat, and be no longer inclined to take the bull. In some countries, where the management of cattle is in other respects conducted with great care, as in the low countries of Holstein and Bremen, generation is left entirely to Nature, the animals all meeting promiscuously on the same pasture. In these countries it is not uncommon for a cow to calve at the age of two years; no degeneracy of the race is apprehended in consequence; but care is taken not to milk so precocious an animal too long. I have known a cow to bear a calf at the age of eighteen months, after having been covered by a bull not older than herself; the calf continued small, but became a good milch cow.

Horned cattle come into heat at all seasons, the time being determined by that of parturition. When cows are well fed, it occurs as early as the twentieth day; but it is usually allowed to pass off, either from fear of trying the animal's strength too much, or because it is not thought proper to accelerate the time of birth. If it occurs again about the fortieth or fiftieth day after parturition, this time must not be neglected, otherwise she will probably not want the bull again. With stalled cattle it is particularly necessary to watch the signs which indicate it. These signs are restlessness, a wandering expression of the eyes and figure, extraordinary cries and lowings, swelling of the sexual organs, an inclination to leap upon the other cows, cessation, or, at all events, suspension of the lacteal secretion. The servants of the cow-house should carefully watch these signs in cows which are not allowed to go out of the stall.

When the desire of copulation does not appear, its absence is due either to weakness or to over feeding, and excess of flesh. In the first case, better food must be given; and it is thus that certain much-boasted specifics, such as oats roasted with salt, lentils, and bruised hemp-seed, produce their effect. The cow should also be made to drink the milk of another which has just come into heat. If, on the contrary, the evil arise from excess of fat, the cow must be made to take more exercise. Some breeders have restored the fecundity of their cows by yoking them to the plow.

The time when the cow comes into heat having been observed, the best time for copulation is from twelve to twenty-four hours afterward; if it be deferred longer, impregnation will probably not be effected.

We may regard as a sign of pregnancy the fact of the cow not giving fresh signs of heat in three weeks after copulation. If, however, the cow should exhibit such signs at this time, it is by no means a sure indication that she has not been impregnated. The swelling of the abdomen is very

deceptive; but after twenty weeks it becomes very perceptible, and frequently the calf may be felt on the right flank of the cow, which is not the case afterward.

The period of gestation is usually 285 days, or forty weeks and five days. Strong, healthy cows sometimes go a week longer; if with their first calf, a week less.

When cows are in an advanced state of pregnancy, they must not, especially when stall-fed, be allowed to go out, excepting to the watering-place; care must also be taken that they are not pushed or squeezed by other cows in leaving or entering the stall.

Miscarriages, or premature deliveries, are attributed to various causes. These misfortunes may undoubtedly be brought on by fodder of bad quality, or which has acquired an unpleasant flavor. As to particular kinds of fodder, such as the straw of buckwheat, frosted cabbage-leaves, or celery-leaves, I do not think it has been proved that they cause these accidents: the opinions of those who make this assertion appear to me to be somewhat prejudiced. Abortion and unfortunate labors are, in animals as in the human race, often epidemic, and probably caused by a peculiar state of the atmosphere, for they sometimes happen in great number in a particular country, without our being able to point to any other cause of general influence.

Nothing can be more ill-founded than the opinion of those who pretend to facilitate calving, particularly in cows which have had difficult labors, by keeping them on short allowance during the last few weeks of their pregnancy, with a view of diminishing the size of the calf. It is not the soft fleshy parts which render parturition difficult, but the whole mass of the bones, and these are formed at an earlier period. Bad feeding deprives the cow of that strength of which she stands so much in need at the time of calving, and diminishes the quantity of her milk. On the contrary, the food given to the cow when the time of her calving is approaching, should be succulent, easy of digestion, and of small bulk, such as a mash or soup, made of crushed grain, seed, or oil-cakes, or leaven of rye mixed with water: some farmers strongly recommend boiled lentils for this purpose. Messes of this description greatly forward the secretion of milk by stimulating the lacteal vessels: they are therefore very useful, both at the time of calving and for a few days after, and the more so because they enable us to diminish the quantity of dry fodder, and such as have a tendency to swell.

The signs of approaching calving are as follows: The udder becomes distended, partially filled with milk; the generative organs swell; there are formed above the vertebræ of the tail two little hollows, which gradually increase in depth, and yield to the touch; the cow becomes restless, continually lying down and rising again; often looks toward her hinder parts and continues lowing at intervals. She must then be supplied with a larger quantity of litter to protect the calf from injury; to a certain extent also she should be watched. In other respects everything is left to Nature. Some cows bring forth standing, others lying down.

The fore-feet, on which the head rests, are the first to show themselves, and the whole body soon follows, being expelled by the efforts of the mother; it is, however, not as with most animals, the head, but the chest which has the greatest difficulty in passing. The umbilical cord divides spontaneously; if not, it may be tied a full inch from the belly, and cut off an inch lower.

If the calf is intended to suckle, it is presented to the mother in order that she may lick it; if, on the contrary, it is to be habituated to drink milk, it is immediately to be removed to the place intended for it.

The after-birth and bladder, full of liquid, in which the calf was enclosed in its mother's body, usually come away spontaneously: to favor their expulsion it is only necessary to supply the cow with succulent food, or a mess containing starch, &c.

Calving is sometimes attended with difficulties, arising from a bad position of the calf in its mother's womb. This evil may be greatly diminished by skillful and judicious aid. The first thing to be done in such a case is to obtain an exact idea of the position in which the calf ought to be placed, and of its actual deviation from that position. By gently thrusting the hand into the womb this deviation may not only be ascertained, but in most cases, corrected by turning the calf. The usual cause of resistance is a false position of one of the fore-legs, or the whole body, in consequence of which the ear or forehead shows itself first, instead of the muzzle. Force must no more be applied in this case than it would be to make anything pass into the gullet; any violent traction may be fatal, whereas Nature will assist if we only give her time. All assistance given must be guided by discretion; misdirected aid may do an infinite amount of mischief, and is too often fatal: this I know from experience. As, however, this is not the place for teaching the obstetric art, I pass it over, strongly recommending all farmers who pay any attention to their cattle, to avail themselves of every opportunity of acquiring information on this matter, since in the country it is not always possible to obtain the assistance of skillful veterinary surgeons. In other respects, however, it is best to leave all to Nature and chance; for without proper knowledge, we shall be more likely to kill the cow and her calf than to save her.

There are two modes of nourishing and rearing the calf during the first period of its life:

(*a*). To let it suck.

(*b*). To make it drink milk.

When the former method is adopted, the mother and calf are accustomed to it from the birth of the latter, by letting the cow lick it. It is then brought, as soon as it can stand, to the udder of the cow, and immediately begins to suck. The first portion of milk possesses a purgative quality; but this is not injurious, but beneficial to the calf, for it excites the irritability of the intestines, and removes the viscous excrements which have entered them from the womb of the mother. These excrements might be very injurious to the calf if they were to remain longer in the intestines.

But there are still two methods of proceeding: the one consists in leaving the calf with its mother; the other in taking it to her as often as it ought to suck. The former is the more convenient method; but it is objectionable—first, because the calf is almost constantly playing with the udder: and secondly, because it either sucks too much, and exhausts the mother, at the same

time over-feeding itself. or, on the other hand, it sucks too little, and gives rise to deposits of milk; besides, the calf is often in danger of being squeezed to death by its mother, or by a neighboring cow. The other method, which consists in taking the calf to the mother at regular intervals; at first, four or five times a day, and afterward only three times; care being taken each time to notice whether it has left any milk behind it, in order that the surplus, if any, may be drawn off. This method. I say, is more troublesome, requiring continued attention, in order that where there are several calves, none may be neglected: but it is safer, and more conducive both to the health of the calf and an abundant supply of milk in the cow, at the time when the calf is weaned.

After three weeks, the milk is often insufficient for the full nourishment of the calf. A kind of soup may then be given to it, made of oil-cake, coarse meal, bran, or ground corn; potatoes mashed in water; or an infusion of hay, with a small quantity of milk. The calf is allowed to drink as much of this as it likes between the meals which it takes from its mother: the remaining portion of the food which it has not consumed is given to the mother. The calf is thus gradually accustomed to this kind of food: it is allowed to suck only twice a day, and the cow is milked once. A quantity of very good hay is also given to the calf, which it soon learns to eat. Calves which are to be very carefully reared, are allowed to suck in this manner for five or six weeks.

When the calf is to be totally weaned, it is removed as far as possible from its mother, that they may not disturb one another by their cries—the manner in which they make known their ardent desire to be reünited—and that they may forget each other as soon as possible. They must be well fed, that the calf may not lose too much in condition and the cow in milk; this loss is always experienced in some degree on account of the distress which the animals suffer. At the same time that the secretion of milk is favored in this manner, the cow is brought to allow herself to be milked more readily, and not to retain her milk.

If the calf is intended to drink milk instead of sucking, it *must not be allowed to touch the mother*, but must be *immediately removed from her.* I do not agree with those who let the calf suck for the first two or three days, and afterward accustom it to drink.

The calf learns to drink as easily as to suck; provided that, for the first two or three times, the finger wetted with milk be introduced into its mouth, and then its muzzle be thrust into the milk; it soon learns to drink by itself; and I am not aware of any case in which difficulties have been met with in this respect. The first portion of milk is given just as it comes from the cow, or diluted with a little warm water. For the first week, the mother's milk alone is given to the calf. Afterward the milk is taken either warm as it comes from the udders of the cows, or heated with a little boiling water. Some care must be taken in feeding calves in this manner. A proper medium must be observed with regard to quantity, so that the calves may neither take more nourishment than is proper for them, nor suffer from deficiency of food. Calves of different ages must, therefore, be kept separate, and the milk measured out to them accordingly. For the first week, 4 lbs. per day are sufficient; 8 lbs. should be given in the second; and 12 lbs. in the third: the quantity must, however, be gradually increased. The milk is always given to the calves in three separate portions. In the fourth week, the quantity of milk is not increased, but liquid food is added to it. of the same nature as that given to sucking calves. In the fifth week, skimmed milk not curdled is given to them; and they begin to eat a little hay, with potatoes, beet-root, &c. These substances, however, are given in small portions only, being put into the manger, chopped very finely. In the sixth week, the quantity of solid food is increased; and in the seventh, they are able to dispense with the milk and soup; if possible, however, a little skimmed milk is given to them, either sweet or curdled. From that time. I give them the same food as the cows, viz., raw potatoes and hay, while they are on winter food, and afterward green-meat of all kinds. When they are ten or twelve weeks old they are turned out to grass; excepting, however, the castrated calves, which are usually left in the stall.

I am aware that some persons object to green-meat and pasturage, apprehending that corpulence and weakness of the digestive organs may be thus produced, and accordingly they give their calves nothing but very fine hay and corn for the first nine months; but I have never known the slightest disadvantage to result from the use of green food; on the contrary, my calves have always continued very healthy upon it. There is, however, no objection to the method of feeding with dry fodder, provided the proper kinds can be obtained.

As to grain, I never gave any to my calves, excepting when its price is very low, as was the case in the spring of 1811.

The reasons advanced for allowing calves to suck instead of giving them milk to drink, are not, in my opinion, valid. It is said—

(*a*). That it is natural for calves to suck, and unnatural for them to drink.

But our cows are not in a state of nature; neither is the end for which we keep them natural. Nature has given milk to cows solely for the nourishment of their calves; but our object is to leave as little as possible of this milk for the calves, because we wish to use it in another manner.

(*b*). That we cannot milk the cow so completely as the calf does by sucking.

A dairy-maid drains the last drop of milk from the udder of the cow and the four teats, better than the calf usually does. The calf either does not suck excepting when it is thirsty. and does not draw all the milk contained in the udder, or else it plays with the teat, and takes only a few mouthfuls now and then, leaving the thickest part of the milk behind. It often accustoms itself to certain teats only—to those on one side, for instance; and then the others lose their milk and dry up.

(*c*). That the practice of feeding calves by giving them milk to drink does not succeed in large cow-houses, because the method cannot be pursued with all the care and attention that it requires, and hence, that it can only be usefully applied when the number of animals is small.

This is contrary to experience. When calves are classified, and fed according to their ages, the most exact order can be observed in feeding them: when, on the contrary, they are taken to their mothers to suck, it is easy to pass one of them over. Moreover, the taking of them to their mothers occupies more time than giving them milk to drink. If, again, the calves are to suck at

the time when the cows go out to grass, the mothers must be kept in the stall, and fed in a different manner from the rest.

Moreover, when calves drink milk instead of sucking, they remain quiet in the stall, and are not annoyed and distressed by being first taken to their mothers and then removed. Milk given to calves in measured portions, according to their ages, does them more good than they would receive by sucking sometimes a large and sometimes a small quantity. They are not exposed to indigestion from excess of nourishment; experience shows, indeed, that calves fed in this manner are less subject to diarrhœa than those which suck. The quantity of milk can also be proportioned to the strength and appetite of each calf; whereas, a calf brought up at the teat of its mother, is either unable to consume all her milk, or does not find a sufficient quantity.

The chief motive for preferring the method of making the calves drink is, that they become more easily and gradually accustomed not only to do without milk, but also to milk of inferior quality and to a different kind of food. Hence, when weaned, they do not fall off like calves which have been used to suck. The distress of the cow and calf, which they express by long-continued lowings, is also spared. The cow is accustomed to being milked; and as this operation gives her, from the first, an agreeable sensation, she willingly submits herself to the woman who milks her. Lastly, skimmed milk is more easily dispensed with, and thus a saving is effected.

The only case in which it may, *perhaps*, be better to let the calf suck, is when the cow is suckling her first calf; because by this means the lacteal vessels are more effectually opened.

When the method of giving milk to drink is adopted, the following mode of proceeding should be observed.

It is only for the first few days that the calf is fed with its mother's milk: afterward it is sufficient to take care that the milk be taken from cows which have most recently calved: when the calves are three weeks old, they may be fed with any milk, provided it be good.

For the first week it is best to give the milk at its natural temperature; and if it has got cold, to warm it again with a little boiling water. Afterward, the milk may be given at a lower temperature, or even quite cold.

In whatever manner the calves are fed, great care must be taken to prevent them from being seized with diarrhœa, and if they are attacked by this malady, to check it as quickly as possible. The remedy which I have found most efficacious is an extract of rhubarb, made with brandy. Half a pound of brandy is put upon an ounce of rhubarb, the mixture is exposed for four-and-twenty hours to a gentle heat, and frequently shaken. This tincture is then strained off, and a spoonful of it given twice a day to the sick calf. The malady generally ceases after the calf has swallowed a few spoonfuls; if not, five drops of tincture of opium may be added to each dose. We must then be more cautious in letting the calf drink, and not oblige it to do so until it has regained its appetite. Some persons speak highly of a broth made with lentils and acorns, roasted like coffee.

A calf which has had good nourishment during the first year of its life, may in the second be fed more sparingly, and on less abundant pasturage; provided, however, that the saving be not carried so far as to cause the animal to become lean and sickly.

During the third year's winter, it may be fed upon good chopped straw, mixed with a little hay. A young cow in calf for the first time must have better fodder, and both the quantity and quality of her food must be increased as she approaches the termination of her pregnancy.

Many persons do not consider it profitable to rear cattle; they estimate the expense of bringing up a cow at a higher rate than the purchase of good cattle. Many rural establishments, indeed, are not adapted for the rearing of young cattle; this is the case, for instance, where cows are taken in singly for a fixed sum. To me, however, it appears that the uniformity of breed which we obtain by rearing cattle ourselves is so valuable, that I should recommend the practice, even when it actually costs more than purchasing. But I do not think that this will be the case under ordinary circumstances, or unless there should be an opportunity of selling the milk fresh and at a high price.

When we know the annual return which a cow yields, we calculate as follows: for the first two years, a calf costs at most half as much as a cow; and in the third year, making even large allowance, the same sum as a cow; so that the whole expense is equal to that of two cows for a year: now it is rarely possible to purchase a young cow, without blemish, for less than this. The advantages of having cattle accustomed to a certain mode of treatment and a certain pasturage are well known, and they are greater in proportion to the inferiority of the pasturage.

If we do not intend to rear the calves, we must endeavor to get rid of them as soon as possible, that we may have the advantage of the milk.

The fattening of calves can be profitable in particular circumstances only—where good calves are bought at high prices for consumption in large towns, and where, also, notwithstanding the vicinity of these towns, there is no better way of disposing of the milk, either by selling it in its natural state, making it into butter and cheese, or using it in any other way.

Calves are fattened in two ways:

(*a*). On milk alone. This mode of feeding always produces the best and whitest meat, and is likewise more easy of application than any other. For calves which are to be fattened, the practice of suckling is attended with fewer inconveniences, because they are sold immediately after being weaned. But when a large number are fattened at once, they must be taken to their mothers or nurses at stated hours. It is necessary to accustom some of the cows to suckle calves which are not their own; some will do so without resistance. These cows may be used as nurses as long as their milk continues, and, if well fed, may thus be made to yield a larger return than otherwise; but they become quite unfit for milking. When fatted calves have attained the age of eight or twelve weeks, their mother's milk is often insufficient for fattening them completely: recourse is then had to other cows as nurses.

(*b*). By food of a different nature, given to them first in addition to their milk, and afterward alone.

In this case, all sorts of mashes are provided for them, made from linseed, cakes of linseed, oat-

meal gruel, boiled potatoes or turnips, and eggs; sometimes, also, with old white bread which has remained unsold at bakers' shops, and may be obtained at a low price. These mashes are given to the calves either alone or mixed with milk. In many parts of the country, and even in towns, there are persons who make a trade of fattening calves, and buy them very young for this purpose. To the farmer this mode of fattening calves is only of secondary importance.

The age of horned-cattle cannot be determined by their teeth with the same accuracy as that of horses and sheep. Of the eight incisors of the lower jaw, which the calf brings with him into the world, or acquires very soon after, the two middle ones are usually shed between the twelfth and eighteenth month, and replaced by larger ones. After the second year, the next two teeth are changed in a similar manner, and so on every year. If the calves are very well fed, this change goes on rapidly; if not, it is retarded; and, generally speaking, the course of nature is less regular in horned-cattle than in other animals, and consequently, in young animals of this class, the indications of the teeth are very deceptive.

It is a more general practice to look to the horns for indications of age; but the information which they furnish is likewise rather vague. In oxen, the lower ring, that which is nearest to the root of the horn, makes its appearnce in the fifth year: in cows, this ring shows itself after they have borne their first calf; after that, a new ring is formed every year, and pushes the second forward. Young cattle do not shed their horns and acquire new ones, as is stated in a manual of the economy of live stock lately published. Some persons profess to have observed that cows do not acquire a distinct ring unless they have calved during the year; but that, in such a case, the space between the rings is proportionally larger. When they miscarry, we may expect the ring to be less distinct. I think I have observed this in some instances, but I do not regard it as an invariable rule. It is certain, however, that a regular disposition of the rings is a characteristic mark of a cow which has always been a good breeder, and that in one which has been sickly the rings vary both in strength and distance. In old animals the rings are not very distinct; indeed, they can scarcely been counted.—The horns, which at first are strong at the root, and get gradually thinner at the extremities, become, after the ninth or tenth year, thicker at top than at bottom. Other marks of more advanced age are, a deepening of the cavity above the eyes—also a deepening of the hind-quarters, increased size of the hoofs, and the growth of white hair about the eyes. The latter may, however, be an individual peculiarity.

Feeding of Cattle.

The feeding of cattle is divided into summer and winter feeding. We shall first speak of winter feeding.

The winter food of cattle usually consists of dry fodder, hay and straw. The proportions in which these two kinds of fodder are given are very variable, depending on the means and circumstances of the rural establishment. Cattle are sometimes fed on straw alone during winter; but when reduced to this food, they not only become unprofitable, but likewise diminish to the last degree in flesh and strength. In some instances, this effect has not been observed to result from straw-feeding; but in such cases, the straw has been mixed with a large quantity of other kinds of grass, or some portion of grain has remained in the ear: it is well known, indeed, that in some rural establishments, the straw, especially that of oats, is for this purpose not wholly deprived of the grain which it contains. When no description of hay can be obtained for feeding the cows, it is usual to give them all kinds of refuse, independently of the husk of corn and the residue of the grain; and when they are near calving, a mash, composed of meal, bruised corn, oil-cakes, or other matters of a similar nature, are provided, to keep up their strength a little.

It is only the straw of plants which bear a great quantity of leaves, such as peas, vetches, haricots, lentils and buckwheat, that contains a larger supply of nourishment. Its nutritive power is in proportion to the greenness of the crop when mown. Millet and maize straw, when properly prepared, likewise belong to the more nutritious class.

Among the ordinary corn-straw, that of wheat is undoubtedly best adapted for fodder; next in value is the straw of oats and barley, which is also, generally speaking, more abundant in leaves; the least nourishing of all is that of full-grown rye.

But it is more common to give straw mixed with hay. The feed of cattle is usually considered good, when 1000 lbs. of hay can be allowed to each animal during winter, making about 6 lbs. per day; this quantity, however, is not distributed weekly over the whole winter season, but saved, for the most part, till the time of calving; 8 or 10 lbs. per day is considered as good feed. It is certain, however, that an ordinary sized cow, which receives no other nourishing food, ought to have 12 lbs. of hay per day to keep her in perfect health: and 20 lbs. if she is also required to yield a good supply of milk. A large cow requires 20 lbs. per day; and if she gives milk, and we wish to keep up the supply, she ought to have 30 lbs. When only a small quantity of hay is given, it is mixed and cut up with straw.

For winter feeding, it is almost universally thought necessary to chop the straw. The chopped straw is divided into scheffels, one of which, coarsely divided for horned-cattle, weighs about 9 lbs., taking the straw of spring and autumn corn together. For an ordinary native cow, from three-quarters to one scheffel per day is thought sufficient.

The cutting of straw requires considerable labor. With an ordinary machine, of the largest size, it is calculated that a man can chop 36 scheffels per day, but not very finely. Various machines have, however, been invented, by means of which a man can get through double or triple the quantity, without more trouble. Their mechanism is so contrived that the straw is pushed forward by cylinders, which, at each cut, present a certain length of it to the knife. The knives, or blades, are of the usual form, but larger; and as the workman can devote his whole time and strength to the raising and lowering of the knife, he can make twice as many cuts in the same time, and put more force into them. In this manner, provided that care has been taken to place the box a little higher than usual, each cut will furnish about a third more of chopped straw. Sometimes the blades are fixed to a wheel, the circumference of which is loaded in order to give it greater momentum; when

its inertia has been once overcome, it merely requires to be kept moving to do all the work.—Sometimes only one blade is attached to this wheel; sometimes there are two or three. A machine brought from England, which had three knives, and was well made, could not, on account of its great friction, be kept in action by one man; and when the knives were blunted, two men were not sufficient to move it. The one-bladed machine is generally preferred. *Karsten*, of Rostock, has given in the "Annalen des Ackerbaues," IIIer. Band. S. 507, the description of such a machine, made according to Lester's model, and with the improvements devised by himself. This machine is well executed at Rostock, by M. Haak, and at present, also, at Berlin, by Schulz, the mechanist, who sells it for 50 rix-dollars. In rural establishments of considerable magnitude large machines of this kind are also used; they are set in motion by draught cattle, or even by wind or water, and produce a large quantity of chopped straw in a short time. But all these machines, especially the more complicated, are liable to this defect, that something or other in them is apt to get deranged or broken, and in the country it is difficult to find a man capable of repairing the mischief. Accordingly, I have known cases in which persons, after laying aside the ordinary machines, have been thrown into great embarrassment by such accidents with the larger ones, and have in consequence become so disgusted with them that they have put them on one side, without making any farther use of them. But it is to be hoped that the mechanical knowledge required for constructing or repairing a machine of this kind, will soon be generally diffused.

When cattle are sparingly fed, and straw is mixed with hay, for the purpose of making them eat as much as possible of the former, and thus making use of the small quantity of nutriment contained in it to deaden the sensation of hunger, the cutting of the straw is indispensable; but when they are well fed, I regard this operation as quite superfluous. The quantity of nutriment in the straw is not increased by it in the slightest degree: on the contrary, the cattle pick out the nutritive portions much better from straw which has not been cut. It is proper, therefore, always to give them the kind of straw which is used for litter. As to good hay, animals eat the whole of it, even though uncut. If the cattle are not hungry, they likewise pick out the best portion of the cut straw, and blow away the rest. We have then the trouble of removing from the manger a quantity of straw which has been cut at considerable expense.

Feeding with grain, whether used as a substitute for hay, or as supplementary to it, cannot be adopted on the large scale with any advantage, unless the price of milk be very high, or that of grain very low. It is certain, indeed, that a few pounds of grain per day considerably increase the quantity of milk; and when we have nothing else to give to the cattle, grain may be used with advantage for this purpose; but it is the dearest of all kinds of fodder. Moreover, milk and butter produced from grain alone are of bad quality, rather cheesy than rich, and have an unpleasant flavor.

Grain, when given to animals in its natural state, often passes through their bodies undigested: it is, therefore, usually ground; but this operation is attended with considerable loss, unless we have a mill of our own, moved either by hand or by water. This operation may, however, be dispensed with, if the grain, before it is given to the cattle, be soaked either in warm or cold water, or else prepared like malt. The development of the saccharine principle by the latter process considerably improves the grain, and renders the milk of better quality. The best kind of grain for milch cows is oats: great benefit is ascribed to a mixture of oats and tares, previously well ground. Barley is more likely than other kinds of grain to produce white, cheesy milk, and the butter produced from it is apt to acquire a bitter taste.

Siftings of grain, bran (whether of the large, middling, or small kind), mill-dust, and the residue of cleansed oats and barley, are most frequently used for feeding cattle.

All these kinds of grain-refuse should be mixed either with cut straw, or, what is better, in the mash. In winter, the latter method makes the cattle more inclined to drink.

We must here speak of the refuse of the brewery. This food has a very favorable influence on the milk: the proprietors of small cow-houses find it very profitable to buy the refuse of the brewers. As it can be obtained at a very cheap rate in summer from town brewers who do not keep their own cattle, we endeaver to keep it in trenches, which, when quite full, are closed with a covering, on which earth is thrown: the residue is thus preserved till winter.

The refuse of the brandy distillery cannot be better employed than for feeding cows; provided, however, that we have a ready sale for our dairy produce. It is either poured into the mangers on cut fodder, by means of pipes fixed for the purpose in stalls expressly adapted for it; or given in the form of mash mixed with water. The sooner it is used the better; for if it become acid even in the slightest degree, it will have a bad effect on the milk. It is best, therefore, to cool it with water as soon as it is taken out of the still. This kind of food must, however, be regarded only as an accessory, and given in moderate quantities; for when used to excess, it injures the health of the cows. The quantity given to a fatted ox must be divided between at least four cows. The residue of the brandy distillery also imparts a disagreeable flavor to milk.

A very attentive farmer used to complain that his calves became sickly, that their flesh stuck to their ribs, and they died. He thinks with me, that the evil arose from the mothers having eaten too much distillers' refuse.

Finally, oil-cakes (the residue of the manufacture of oil), especially those made of linseed, have a very good effect. The best mode of proceeding is to put them into the mash; in which, however, they should be well mixed up. This is effected as follows:—A vertical division is made in the pail with boards, in which a number of small holes are pierced with an auger; the partition is so placed that the smaller space shall occupy a third of the whole. In this space the cake and water are placed, and frequently stirred. The liquid is then transferred to the other division, into which there cannot pass a single morsel of solid cake, but only the mashed portions. The oil-cake mixes gradually with the water which is added to it; care must therefore be taken to add a fresh portion from time to time. This renders the mash particularly agreeable to cattle, and evidently increases the secretion of the milk.

Bad linseed, crushed and boiled in water, forms a very nourishing drink for milch cows. Sparry-

seed is also used for this purpose; not, however, boiled, but merely swelled with warm water. It is recommended as one of the most substantial kinds of food for milch cows.

One of the best kinds of food for horned-cattle, and particularly for cows, and which completely supplies the place of a portion of hay during winter—consists of roots, such as potatoes, mangel-wurzel, cabbage-turnips, transplanted turnips, ruta-bagas, common turnips, carrots, and parsnips. These roots must not, however, be valued at their market price, which is often determined by accident, but according to the outlay necessary for obtaining them by cultivation; it is rare indeed that these plants can be disposed of in the market in large quantities; and if by chance a high price toward spring time should favor such a mode of disposing of part of them, the occurrence must be regarded as merely casual.

In the former part of this work I have spoken of the nutritive power of these vegetables and their value as compared with that of hay; and of the average produce of them which may be expected from a well-cultivated soil; I have also spoken of it more at length elsewhere, when describing the culture of each of these plants. Subsequent observations have convinced me that the proportional nutritive power there ascribed to them is determined with as much precision as we can at present attain. It remains, therefore, only to speak of the mode of using them.

These vegetables are used either raw or boiled. The boiling of potatoes is now performed by steam in almost all places where it is conducted on a large scale, because this method not only produces a saving of wood, but also ensures the proper degree of boiling. The best apparatus for this purpose is now well known, in consequence of the almost universal introduction of the distillation of brandy from potatoes. It consists of a brandy still of the usual form, which, like most of those of the recent manufacture, has no capital, but only a long neck, like that of a retort, from which the vapor is transferred through a tube into the vessel containing the potatoes. The latter is an upright cask, into whose lower part is fixed a false bottom, pierced with holes, to allow the escape of the water condensed in the vessel. The steam-pipes are introduced into this cask, care being taken to keep the lid well closed, and also the door, which is usually placed at the side. The water in the still is then made to boil, and the potatoes become cooked to the proper degree in a much shorter time than they would by being boiled in water.

It has not yet been decided by comparative experiments whether, or to what extent, root-crops, and especially potatoes, are improved for cattle by boiling. Experiments on a small scale seem, however, to show that the difference is not considerable, and does not compensate for the expense of the operation, how strongly soever this method may be recommended by theory and analogy. It is easily seen that cattle eat vegetables in the raw state with as much, and ultimately with more pleasure, than those which are boiled. It is only when potatoes are given in very large quantities, which is the case with fatted cattle, that boiling may be advantageous, by diminishing the laxative property which these vegetables certainly exhibit when eaten in considerable quantities. It is probably for this reason that many persons, particularly in England, who keep cattle in large numbers, recommend boiled potatoes for fatted oxen, and raw ones for milch cows. We shall hereafter speak of feeding on mashes or soups, and the use of root-crops for this purpose.

These vegetables should be cut in pieces, which is done on the small scale with a knife shaped like an S, made expressly for the purpose; and on the large scale by means of various cutting-machines. Several machines have been invented for this purpose; the one best known consists of a strong, solid wheel, armed with three blades, and composed of three triangular pieces of wood, joined together to prevent the passage of the roots. This wheel turns upon an axle in front of a box, in which the roots are placed, and cuts them as they are presented to it. The impetus with which the wheel moves facilitates the labor so much, that a weak person may perform it. The blades are straight, and cut the roots in the form of disks; or they have an undulating edge, and cut them into small, elongated pieces. The latter effect has also been obtained by other cutting pieces placed across. In my opinion it is quite sufficient that the roots be cut into disks or flat slices; and this is even preferable, because small pieces easily adhere together, or become blackened, and ferment when left for some time in that state. Cattle certainly eat them more willingly when they are but coarsely divided; very minute division, indeed, cannot be of any use, excepting to prevent the animals from being swelled up. Curved edges are also more quickly blunted, and more difficult to sharpen.

I am still less disposed to admit the utility of those machines which reduce the roots, either raw or boiled, to a semi-fluid consistence: they are only useful for the distillation of brandy and other preparations made with these roots.

In constructing machines which mash the roots in this manner, the object in view is to mix them better with cut straw, so as to compel the cattle more effectually to eat the latter; but experience has quite altered my opinion on this point; in short, I have seen cattle which had been well fed, and had therefore become rather dainty, constantly endeavor to separate the cut straw from the pieces of root, and get rid of the latter by blowing upon them before they went on with their meal. I therefore have the roots given to them separately, and I find that they eat straw much more willingly when put before them whole, soon after they have eaten the roots, than that which is cut for the purpose of making them swallow it together with the roots.

A mixture of several kinds of roots, or the use of them one after the other, appears to me to be very advantageous. The several kinds of turnip, which contain a greater quantity of saccharine matter, are certainly an improvement to potatoes, which, on the other hand, are more farinaceous; the milk becomes sweeter in consequence, and acquires a better flavor; moreover, the cattle like the change. But the preservation of turnips till spring is much more difficult than that of potatoes; and hence there is positive reason for having the turnips consumed first, the potatoes being reserved for use at a later part of the season.

However nourishing and advantageous these vegetables may be, we must not venture to use them long as the sole food of milch cows. A due proportion of dry fodder should always be added. It is true that the addition of a quantity of unmixed straw may be sufficient, and the cattle will eat it with avidity. But cows thrive best, and yield the greatest quantity of milk, when

part of their food consists of hay. Other cultivators as well as myself have found that when cattle are partly fed on potatoes, it is best to give them half their feed in hay and half in roots, the quantity of the latter being regulated according to their nutritive powers. When, for instance, a cow fed solely on hay, would require 20 lbs. of that substance, we may give her 10 lbs. of hay, and make up the quantity with 20 lbs. of potatoes, 46 lbs. of mangel-wurzel,* 35 lbs. of Swedish turnips, or 52 lbs. of common turnips. When cows eat potatoes, the hay contributes greatly to improve their milk; for when they have nothing but potatoes and straw, the milk produces a white, cheese-like butter, very apt to acquire a bitter taste, as is the case when cows are fed upon meal.†

When one kind of food is to be substituted for another, I have always found it important to make the change gradually. If, for example, cattle have been fed for a long time exclusively on beet-root, and, this kind of food being almost exhausted, we are about to substitute potatoes for it, it is proper, in order to prevent the cows from falling off in their milk, to feed them for a week on beet mixed with potatoes, the quantity of the latter being gradually increased; for although the cattle like the change, still they get so much attached to a particular kind of food to which they have been accustomed, that they do not abandon it suddenly without regret; the effect of the change is first seen in a diminution of the quantity of milk.

The method of giving food in the form of mash or soup has been very generally extolled, both from theoretical and practical considerations, as being well adapted to develop the nutritive principles. It is generally adopted in many countries, particularly in small rural establishments, where great attention is paid to the management of milch cows. Boiling water is poured, either alone or mixed with some nutritive substance, on the cut fodder; the mixture is then brewed and given to the cattle, after it has cooled a little. Roots, or some other farinaceous substance, like those already spoken of, may then be boiled in water, and more intimately mixed with the cut straw. I once tried this kind of food for two winters on twelve or fourteen milch cows, making up the total quantity required with roots and cabbages boiled in water, and obtained a quantity of milk much greater than I could have expected. The food was prepared twice a day, in two tubs, in the morning for the noon and evening meal, and in the evening for that of the following morning, otherwise the liquid would not be sufficiently cool. But though the vessels were frequently washed with lye, I could not prevent the occurrence of acidity during the slow cooling. This acidity, when slight, did no harm; but when it became stronger in consequence of high temperature, it made the food very unpleasant, so that none of the cattle, excepting those which were very hungry, would touch it. Moreover, I found, in the ensuing summer, that my cattle were weakened, and that their digestive powers were impaired; and I lost, during the time of feeding on green-meat, more than I had gained during the winter. I therefore abandoned this mode of feeding, which was likewise very troublesome. I do not think that it can well be adopted in large establishments, or anywhere, indeed, excepting in small concerns where only three or four milch cows are kept, and the water can be warmed in pans; and farther, I think that it is fit only for cows from which we wish to obtain the greatest possible return for a time, and get rid of them afterward.

The mixture already mentioned, of the refuse of the brandy distillery, while yet warm, with cut straw, may be considered as a kind of mash or soup.

In winter, cows should be induced to drink a great deal. They will not drink very cold water, unless compelled by excessive thirst, but tepid water they drink much more willingly. They may, however, be easily induced to drink by simply mixing a small quantity of farinaceous matter with the water; the oil-cake already spoken of is particularly well adapted for this purpose. Cattle should not be made to drink immediately after their meals, but in the intervals.

It is of great importance, in giving food and drink to cattle, to observe regularly the hours to which they are accustomed, and to give them at each time the kind of food which they are in the habit of receiving. At the beginning of the time of winter feeding, the arrangement may be made in almost any way; but when once fixed, it should be adhered to. In my establishment the winter feeding has usually been arranged as follows: Early in the morning the cows are fed with cut straw and hay; at eight or nine o'clock they are watered; at eleven o'clock roots are given to them without any addition, then uncut straw, at three o'clock they are again watered, and, after that, a little uncut hay is given to them. In the evening, they are again supplied with cut fodder, as in the morning, but in smaller quantity; and when they have consumed this, they get another supply of roots. A quantity of straw is then put before them for the night; they eat as much of it as they like, and the rest serves for litter on the morrow. In this part of the country I have never given salt to my horned cattle, because its high price would outweigh all the advantages which it might procure. At one time I used often to give it to them, and I found, beyond all doubt, that it increased the secretion of milk. When, however, it was used in excess, the cattle appeared to grow lean upon it, and the butter acquired a bitter taste.

The arrangement of our stalls makes good litter very advantageous to the cattle. The quantity should be regulated according to the supply of food, especially that of a succulent character.— When cattle are ill fed, and on dry fodder only, three pounds of straw per day are sufficient; but when the supply of food is more abundant, ten pounds are scarcely sufficient to absorb the excrements and urine. In a season when straw is scarce, as was the case in 1811–12, if we should be compelled, in order to save a sufficiency of straw for summer stall-feeding, to reduce the quantity of litter at the same time that we give the cattle an abundant supply of roots, it will be necessary to remove the dung every day, in order to keep the cow-house dry and clean—unless, indeed, we can have recourse to other substances to supply the place of straw. A dry bed, even if it cannot be made soft, is indispensable to the health of cattle.

* I should say 26 lbs. [*French Trans.*

† For the proportion in which potatoes should be given to cattle, see "Die v. Jenaische Versuche," A., in the "Neue Annalen," 3er. bd. 1 stea. st. s. 102; "Die v. Jenaische Versuche," A.

Many persons recommend the practice of currying cows. On fatted cattle this treatment produces a surprising effect, but with cows I never observed any good to result from it that could at all compensate for the trouble it occasioned; the only care required is to keep the udder clean, and wash it before milking.

When a large quantity of litter is given to the cattle, at the same time that they are but poorly fed, the litter may be left under them for a long time. In the contrary case, the dung must be removed or drawn to the back of the stall at least twice a week. The dung is most easily removed by the drag; but the implement must be so formed as to allow of yoking both sides, so that it may not be necessary to turn it, but merely to yoke the horse on the opposite side.

Winter feeding may be calculated to last for seven months.* Pasturage usually continues till the middle of October, and is resumed in the middle of May. We shall hereafter speak of green feeding in winter. It is, however, prudent to reckon upon a fortnight longer, because, if the spring be unfavorable, the grass feeding may be retarded for that time. Especial care is therefore taken to save the hay, because it can also be used in summer, or may be preserved till the following winter. A supply of hay or straw preserved from one year to another affords great security.

We have previously spoken of the various kinds of pasturage, and the extent required per head of cattle.

A pasturage, of which six acres are not sufficient for a cow of proportionate size, can scarcely be considered as cow pasturage, or advantageously used as such. For, where a cow has to seek her food over a large extent of ground, she will not thrive, and her return will be reduced to a very small amount. These very poor pastures are only fit for sheep.

Experience shows that there are pastures particularly well adapted to favor the production of milk in cows, but on which cattle do not fatten; and others, on the contrary, which soon bring cattle into good condition, but do not produce much milk. I am not aware that the cause of this difference has yet been discovered. In many low countries, however, this fact has been so clearly established that pastures are there divided into fattening and milk pastures, and each division is grazed by the kind of cattle properly belonging to it.

Every body knows that pastures, to be good for cows, must be free from acidity. Where the acid principle predominates, cows lose their milk, but oxen thrive well. I shall not pretend to decide whether this effect is owing to a transmission of acidity to grasses and other plants which are otherwise wholesome, or to particular plants which grow upon those lands. *Corn Horse-tail (Equisetum arvense)*, and *Marsh Horse-tail (Equisetum palustre)*, Colchicum, various species of *Ranunculi* and other marsh-plants, are certainly injurious to horned-cattle, and particularly unfavorable to the production of milk; but animals of this class do not touch these plants unless compelled by hunger.

Upland pastures, when rich enough to enable a cow to find full nourishment on three acres, produce a larger secretion of milk than lowland pastures—provided, however, that the race of cattle be adapted to them, for a large cow of the low countries would not easily find sufficient nourishment on three acres of upland pasture.

Outlying pastures lose much of their value from the distance which the cattle have to travel in going to them and returning: it is commonly said that the milk is lost on the road. The more quiet the cattle are on the pasture ground, the more profitable will they be found. It is for this reason that pasturage on the fields under the *alternate system of culture* is so valuable: on fields completely enclosed, where there is no occasion for either dog or herdsman, cattle enjoy perfect tranquillity, especially when left on them night and day.

Opinions are divided respecting the propriety of leaving cattle on the pastures during the night. Some persons think that it is most advantageous to take them back to the stall, not only for the sake of their health, but also to obtain a greater quantity of manure. But most cultivators who follow the *alternate system*, especially those who make it their business to keep cows, are positively of opinion that the cows should be left on the pastures for the night-time, during the warmest months of summer, as otherwise their milk is considerably diminished. The assertions of some parties respecting the hurtful influence of dew and fog, and the injurious quality of grass still wet with dew, are altogether without foundation, at least with regard to high grounds enjoying a salubrious atmosphere. It is only in damp situations, in the midst of marshes, that fog can be hurtful. In the cold nights of spring and autumn, however, the cattle should always be taken back to the stall; and if in the morning, before they are sent to the pasturage, a little dry fodder, though it be merely good straw, can be given to them, they will be much benefited by it.

With regard to other kinds of pastures, it is rarely advantageous to leave cattle on them for the night, if it be only because the dung is lost upon them. On the enclosed fields of the *alternate system*, on the contrary, the dung is of some use to the land, especially if the cattle are all collected for the night on the field which is first to be brought into cultivation.

When cattle are tended by a herdsman, the manner in which they are treated is by no means indifferent. The herdsman should, as far as possible, leave the cattle to themselves, or, at all events, guide or drive them before him with gentleness, and never allow the dog to hunt them.—As the cattle advance in grazing, the herdsman should guide them in such a manner that they may always walk before the wind, and never have it in their faces. But it is of especial importance that the cattle be not disturbed when they lie down to ruminate; they then require absolute repose.

The question as to whether a cow gives more milk at pasturage or when stall-fed may perhaps be decided in favor of the former, supposing that she is in both cases equally well supplied with

* On the borders of the Lake of Geneva the time is six months, from the 10th of November till the 10th of May. Between the Alps and the Appenines pasturage is sometimes to be had from the beginning of April; and in places where, as in Bologna, it is the practice to cut the heads of wheat once, twice, or even three times, to prevent it from being laid, these heads are used to introduce the cattle to summer feeding on green-meat. [*French Trans.*

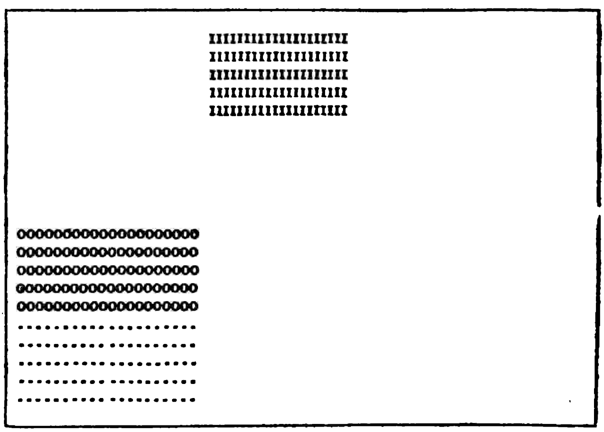
food, and tended with the same care. Indeed, I am not acquainted with a single instance in which the total product of milk from a whole herd has been so high, on the average, during stall-feeding, as when the cows are fed on the best pasturage. This latter case, however, is but seldom realized.

The method of tethering cattle on the pasture, called by the Germans *tüdern*, or *töddern*, holds the middle place between pasturage and stall-feeding. This method consists in fastening the animal by a cord, having a swivel adapted to it at the end which goes round the neck, and is fixed to a stake at the other end, where there is often a second swivel. As applied to separate animals, this method is pretty generally known; but, as far as I am aware, its application to herds of more than a hundred cattle is confined to Denmark; for this reason I think it right to transcribe, in this place, the description of the method which has been communicated to me.

In applying this method on the large scale, it is necessary to keep the animals as close together as possible—first, that every part of the ground may be turned to account; secondly, that the dairymaids may not have too far to go in carrying the milk to the cart which is to take it away, and is placed for that purpose in the center of the herd; and thirdly, that the dung of the cattle may be equally distributed. The cows are usually collected in divisions of twenty, because that is the number which a dairymaid can milk. In commencing the pasturage of a field according to this method, the cows are placed in a row, the last being fastened at the extremity of the field. The distance between one cow and the next depends upon the length of the cord, and that again is determined by the quality of the pasturage. At Thorserg, where second-year clovers are consumed in this manner, the cords are 10 feet long, Rhine measure. The stakes are so placed that the cows can approach close together, without, however, touching one another; and thus all parts of the surface are reached by their teeth. When the first division has been cropped, the second is arranged at a distance varying from 60 to 80 feet, according as the soil is good or bad; the third and fourth divisions are arranged in the same manner.

The spaces left between the preceding are next grazed; for which purpose the stakes are removed, and planted forward, after the space determined by the length of the cord has been grazed; and this succession is continued till the first division has come into the position previously occupied by the second—the second into that of the third, &c.

The following figure will give an idea of the mode of proceeding:



Let the enclosed space represent a field of pasture-ground, and the dotted lines five divisions of twenty cows each. The cows graze the portion assigned to them until it is completely exhausted. The whole herd is then moved forward to the spaces marked oooooooooooooooooooo. When the herd has in this manner reached the extremity of the field, they come back in the same order as shown by the marks, IIIIIIIIIIIIIIIIII, and so on till the whole field is depastured.

As the whole herd must not only frequently be moved, but also led to the watering place, it is essential that a man be able to lead twenty cows and more at once. For this purpose the cows must be fastened together, which is done as follows: The herdsman begins at the right wing of the first division, attaching the cord to the first cow in such a manner that he can suspend it from the horns of the second. He proceeds in the same manner with the cord of the second cow, which he attaches to the horns of the third, and thus he links together twenty cows in one line. The cowherd walks on the left wing, and leads the animals to water; they drink without being unfastened. On returning, he fixes in the ground the stake of the cow which he has been leading on the left wing; he then takes the cord of the second cow which was attached to the horns of the third, and fixes it in like manner, proceeding in the same way with the third, fourth, &c. In linking them together, he always begins on the right; in separating and fastening them to the stake, on the left.

If, as is usually the case with fields of this description, the watering place be near at hand, the herdsman takes only one division at a time. But if it be distant, or if the cattle are to be led to another field at some distance from that in which they have been grazing, several files are united together. This is easily done by attaching the cord of the cow on the left side of the second row,

to the horns of the one at the left side of the first row, &c. But when the cows are to be watered, the several divisions must be again disunited.

The facility of this method of linking and separating depends partly on the animal being accustomed to it, but more on the skill of the herdsman. Sometimes one man is required for twenty cows; at other times, one cowherd can without difficulty take care of fifty.

The cattle become so readily accustomed to the method, that after a time they place themselves in rows and divisions, almost of their own accord; and thus the care and circumspection required become much less burthensome than when the cattle are stall-fed. The method under consideration resembles stall-feeding, however, in this respect, that the cattle injure but very little of the fodder with their feet, and may be made to consume the crop in the most favorable stage of its growth, after which vegetation soon recommences; hence the quantity of land required for supporting an animal is not greater than that which would be necessary in stall-feeding.

A comparative experiment, made at Thorserg, on the relative advantages of *grazing with the tether* and stall-feeding, gives the following results:

Four cows, stall-fed, during twelve days, gave 1,110 lbs. of milk; extent of land required, 2,172 square fathoms; quantity consumed, 6,144 lbs. clover: which gives for one cow in a day, 23 1-8 lbs. of milk, 45 1-4 square fathoms, 128 lbs. clover.

Four cows pastured by the tether for twelve days, gave 950 2-5 lbs. of milk; extent of land grazed, 1,842 square fathoms: which gives for one cow in a day, 194 4-5 lbs. milk, 38 3-8 square fathoms.

Therefore the stall-feeding consumed the produce of 330 square fathoms more than the *pasturage by tether*; on the other hand, the quantity of milk was greater by 159 3-5 lbs. in the former case than in the latter.

For 1 lb. of milk the stall feeding required 1 531-555 square fathoms: the *pasturage by tether* 1 1117-1188 square fathoms of clover-land.

Therefore, according to the same result, the 330 square fathoms which remained untouched in the *pasturage by tether* of a given number of cows would, if consumed in the same manner, have yielded 170 1-5 lbs. of milk, which, with the 950 2-5 lbs. actually produced by the four cows fed in that manner, gives a total of 1,120 3-5 lbs. of milk: as much therefore (and even 10 3-5 lbs. more) than the same number of cows yielded when stall-fed on the produce of the same extent of clover-land.

According to this experiment the same quantity of milk is obtained from a given quantity of clover ready for the scythe, and the same number of cattle may be fed upon it, whether they are *pastured by the tether* or stall-fed. Hence, there is no peculiar advantage on either side.

It must be remembered, however, that when cattle are stall-fed, the quantity of dung obtained is two-thirds greater; for when they are *tethered* there is not more than one-third of the dung profitably applied to the land. On the other hand, the stall-feeding must be charged with the additional expense of mowing and carrying the clover.

It will probably be disadvantageous to have the same clover-field grazed twice by cattle thus tethered, because the excrements which they leave on the ground during the first grazing may disgust them with the second shoot. It is better, therefore, to make the second crop into dry fodder.

I have previously spoken of the advantages which stall-feeding confers on rural economy in general, and I have afterward described the cultivation of plants intended for feeding cattle. It only remains, therefore, to speak of the mode of giving this feed and tending the cattle.

A stall properly arranged for feeding greatly facilitates the work to be done; and of all arrangements which can be made, that which I have recommended in the "Introduction to Bergent's Economy of Live Stock" appears to me to be the most convenient, because it enables us to spread the fodder well, and give it to the cattle in small portions and in the most convenient manner.

Some persons, thinking it better to feed their cattle in the open air, have enclosed a yard with hedges, furnished it with mangers and racks, and put their cattle in it, leaving them at liberty to walk about as they pleased. This treatment has been adopted from the notion that free air and exercise would be more favorable to the cattle than constant rest in the stall. In the long run, however, experience has not been in favor of this method, but has shown it to be attended with the following inconveniences: The cattle eat the fodder too greedily, but against each other: and the weaker animals are completely driven from their food by the others. The dung is also deteriorated in quality. From theoretical considerations, we might perhaps be apprehensive lest the close air and confinement of the stall should be injurious to the cattle; but experience shows us very clearly that this is not the case, and that stall-fed cattle, when well treated, always continue healthy, yield abundance of milk, and live to an advanced age: this has been the case even when they have never quitted the stall. But it is undoubtedly better to let them go out twice a day for the sake of removing the dung, watering them, and, if necessary, letting them bathe.

The places for the cattle should be so disposed as to leave the animals a proper quantity of room in proportion to their size, and particularly to allow of sufficient depth for removing the dung from under them, and heaping it up against the wall, and at the same time leaving a free passage behind them. It is also necessary that there be a gutter behind the cattle, by which the large quantity of urine produced by a plentiful supply of green-meat may drain off, or be removed and swept away. The supply of liquid manure increases or diminishes according to the quantity of litter put under the cattle; but it is rarely possible to put a sufficient quantity for absorbing the whole of the urine; for that purpose 15 lbs. of straw, and even more, would be required for each head of cattle.

When the stalls are well built, boarded, and furnished with proper drains, and care is taken to

keep the places occupied by the cattle clean with the broom, the litter may be dispensed with. This is proved by the experience of cultivators in the Netherlands, on the banks of the Rhine, and in Switzerland, and even among ourselves by several farming establishments which have been introduced by persons from those countries. This is the best mode of keeping the cattle clean: but where there is no scarcity of straw, the use of litter is preferable, inasmuch as it increases the quantity of manure.*

The stall should be furnished with windows for the admission of light and air, and capable of being opened or shut at pleasure.

Clover is usually regarded as the only proper subsistence for summer stall-feeding, but this opinion is altogether unfounded. This is not, and cannot, be the case, unless the stall-feeding is to be continued for a few months only, instead of being used as a constancy. Cows were stall-fed in summer before clover was known. It is certain, however, that when the clover is in season, it furnishes the best and cheapest fodder that can be had. But green-feeding commences before clover is ready for mowing: and this kind of fodder fails, not only between the first and second crop, but also toward the end of summer. It is therefore necessary to procure other kinds of green food to precede the clover, and fill up the voids which that plant would leave in the course of summer feeding.

The plant best suited for the first kind of green food is autumn colza, sown toward the end of the preceding year. Next comes rye, which has been sown for the purpose. Both these articles are sown on part of the field intended for root-crops, or perhaps for late vetches, so that it will be necessary to break up the soil as soon as they are gathered. The sowing of these plants costs nothing beyond the seed and the labor of spreading and covering it. When wheat sown in autumn is particularly strong, the heads may be cut off, and used to aid in feeding the cattle. By this time the lucerne is ready for mowing: it is always the main prop of the stall-feeding. Then the clover begins to put forth its flowers, and reaches the stage in which it may be most advantageously given to the cattle. When the first crop begins to get too hard, recourse is to be had to tares and various mixtures of this plant, with others which cannot be dispensed with, unless we have a field of lucerne of considerable extent to serve as a supplement to the summer feeding. At this time also spurry may be brought into use. Then the second crop of clover is ready for mowing; and if perchance it should not be very abundant, or we wish to make it into hay, in order to plow up the stubble sooner, we must then resort to a mixture of tares sown later than the rest—buckwheat, early sown colza, spurry, and the third crop of lucerne.† Then, with perhaps a third clover, a fourth of lucerne, assisted by the annual fodder-plants just spoken of, the end of September is reached, at which time the cattle may be abundantly supplied with cabbage-leaves, mangel-wurzel, turnips of various kinds, and even the haulm of of potatoes; and thus without any other assistance, beyond perhaps a little hay or straw, we reach the end of October.

Stall-feeding, on green-meat, may thus be continued for six entire months, that is to say, as long as, or even longer than pasturage. But it is often thought desirable to let the cattle go out during part of the day; when, for instance, advantage can be taken of a nutritious stubble on the corn-fields, particularly on those which bear clover sometimes, or of which clover has been twice mown, and is intended to stand. In this case, it is sufficient to give the cattle a small quantity of light food before sending them to the field, and thus they are treated by the system commonly called *half-stall-feeding*.

The method of *half-stall-feeding*, united with pasturage during part of the day, has gained many advocates, and is particularly well adapted to the circumstances of certain rural establishments, where, for instance, there is a pasture which, from liability to inundation, or some other cause, cannot be used in any other way, and is, at the same time, insufficient for the full nourishment of the required number of cattle. For this reason, the system of *half-stall-feeding* is established with great success in several rural establishments on the banks of the Elbe, Weser, and other rivers, not kept in by dykes, or enclosing within their dykes lands which are fertile but exposed to inundation, and therefore not adapted to the ordinary system of cultivation. It is certain that this variety of diet stimulates the appetite of the cattle, and causes them to eat more and yield a larger quantity of milk, provided always that the pasturage be of good quality, for if bad, it will only serve to dissipate the milk produced by stall-feeding. Positive injury, therefore, often results from turning cows out of the stall merely for the sake of turning a bad pasture to account.

It is only in very small rural establishments that green-meat should be carried by servants in fodder-baskets. This practice is, however, sometimes adopted in establishments containing from twenty to thirty head of cattle. I consider it quite inconsistent with a good system of management, whatever may be the circumstances of the establishment. Sometimes, the carriage is performed by the plow horses; they take the fodder-wagon to the field when they go to work in the morning, and bring it home loaded when they return at noon or in the evening. This plan seems to me to occasion much disorder and loss of time.

The labor may be very well executed by the cows, if they are put to it in turns; some of them

* I think that the science of rural economy has yet much to learn upon this point. It is clear that the straw adds little of itself to the quantity of nutriment contained in the manure, increasing its bulk rather than its intrinsic value; above all, we must remember that the real value added to the manure is not equal to the cost of the straw in its natural state. On the other hand, the straw used in feeding cattle, though not very substantial, nevertheless contributes something toward their nourishment, and it is, undoubtedly, more animalized by passing through the bodies of the animals, and therefore better adapted for manure, than when simply mixed with the dung of the cattle, without passing through their bodies. It appears to me, then, that by using straw to feed cattle, of a particular kind, we may gain a great deal both in the use of the straw and in the quality of the manure produced from it. This, however, cannot be done with milch cows: for, by making one-quarter of their nourishment consist of straw, the quantity of milk would be reduced by about two-thirds. Neither can this kind of food be given to young animals; for it would retard their growth. It can, therefore, only be given to the working cattle during the time when they are but little employed. [French Trans.

† Or rather the fourth, in places where this plant grows luxuriantly. [French Trans.

may be readily accustomed to it. This light work, far from injuring their health, or diminishing the quantity of their milk, is always found to agree with them perfectly well. One or two oxen intended for sale in the autumn may also be devoted to this work. It is true that they will eat a great deal, both on arriving at the field and on returning home, but they will fatten sufficiently to repay the value of the fodder which they have consumed.

Oxen daily employed in this work soon become so much accustomed to it, that they will go alone with the wagon to the field, and bring it back again alone when loaded.

When the labor of mowing and gathering the green crop is well regulated, the number of persons engaged in supplying food for a herd of forty oxen is not greater than would be required to take care of the same number while grazing; for a man who would be occupied in taking care of cows out at grass, may very well mow and bring in the necessary quantity of fodder. The dairymaids assist in distributing the fodder, and this light labor is amply repaid by the saving of the distance which they would have to walk in going to the pasturage, and of the additional trouble of milking in the open field. The trouble of clearing the dung out of the stalls may very well be laid to the account of the larger quantity of manure obtained.

Many persons consider it absolutely necessary to cut the clover, an operation which occasions great increase of labor. I consider it altogether superfluous, excepting during the first week of the transition from dry to green fodder, a time at which the latter is not abundant but very active.—The object of this method is to save fodder, but if this end is actually attained, the quantity of milk is at the same time diminished. It is thought also that the same method prevents the loss occasioned by the cattle throwing their long green food about in the stall as they do in the fly season, but the quantity lost in this manner is quite insignificant, and, in my opinion, far exceeded by that which the cattle leave in the mangers when the clover is too finely divided. Cut green-meat soon becomes heated and completely spoiled. The *hove*, or *blown*, which is so much dreaded from feeding on long clover, is not at all likely to occur if the cattle are regularly fed, and never allowed to suffer from hunger and afterward eat to excess. For twenty-six years, during which my cattle have been stall-fed, I have never lost an animal fed on clover by this accident. It is true that long clover sometimes has a laxative effect on cattle, and that this inconvenience is obviated when the clover is cut up with straw. But this evil may be just as well prevented, or, at all events, diminished, by giving the cattle a quantity of uncut straw, which they will eat with avidity when their bowels are relaxed by the use of succulent green food. In that case, it is also very useful to give the animals a little dried hay in the morning.

It is of great importance to distribute the fodder in such a manner that the cattle may not eat it too fast, which they will be sure to do if the quantity of food intended for a meal be given to them all at once. Each meal, of the three usually given in the course of the day, should be subdivided into three portions, to be eaten at intervals of an hour: for example, in the morning, at five, six, and seven o'clock; in the middle of the day at twelve, one, and two o'clock; and in the evening, at seven, eight, and nine o'clock.

The cattle must be watered in the intervals between their meals, and not immediately after they have eaten: in the forenoon at eleven o'clock, and in the evening about six o'clock. Good pond-water is usually preferred by cattle to river or spring water.

In places where it is possible, we must not neglect to have a ford or bathing-place, and send the cattle to it twice a day. There is nothing more refreshing to cattle in summer, or more conducive to their health and cleanliness.

In the arrangement of cultivation, matters must be so disposed as always to ensure a sufficiency, or even a superabundance of clover or other green food for the cattle, so that if one sort should fail, we may have recourse to another. As soon as we perceive that the quantity is greater than we require, and that the fodder may become too much hardened, we must make it into hay and pass to another kind of food.

It is impossible to indicate, even approximately, the extent of each kind of fodder-plants required for supporting an animal, for the produce of a field is so variable, that in one year it may be double what it was in the preceding. On good barley land, an acre of fodder-plants will generally be sufficient for one large animal. I have even known cases in which 100 perches, or 144 square feet, have been sufficient. But prudence forbids us to reckon upon less than an acre and a half even of good land, favorable to the growth of fodder-plants, and two acres of a less favorable soil. It will not often happen that the whole produce of this extent of ground will be used, but no loss will result from this circumstance. If we have contrived to save a supply of hay from the preceding year, which may easily be done when the clover has been successful, there will be no occasion for reckoning on so great an extent of ground for a head of cattle, and consequently a greater number may be maintained; for such a provision is always an available resource.

Alternate feeding on dry and green fodder is always agreeable and beneficial to cattle.

Some cultivators have fed their cattle for the whole summer on dry fodder, chiefly on clover, and speak very highly of the method. But, in the first place, it is very difficult to provide a supply of hay which shall suffice till a fresh crop can be given to the cattle (which should never be done till the latter is thoroughly dry); and secondly, the hay-making is attended with much greater outlay and risk than consumption in the green state. The method in question also appears to me to be attended with great difficulties on account of the magnitude which must be given to the sheds for preserving so large a quantity of hay; in fact, it is necessary first to consume the whole of the last year's produce. Lastly, it is very probable that as the fodder dries, not only the watery portions, but also a great many useful principles are separated from it by evaporation, and that several substances contained in it enter into new combinations. We are not in possession of any comparative experiments on this subject of the degree of accuracy which would be desirable, but only of a few scattered observations; these, however, point to the conclusion that a given quantity of fodder, when consumed as green-meat, is more advantageous, particularly to cows, than when dried.* The

* It is evident that fodder-plants, in drying, lose a great part of their leaves, flowers, and, in general, all their most delicate and substantial parts, which either remain on the ground or are lost on the road; whereas, if

nourishment contained in the fresh juice of plants apparently passes more easily into the blood, and becomes more readily available for nourishment, than when re-dissolved in a foreign liquid.

Milk and butter produced by dry fodder never have so good a flavor as from feeding on green-meat. It is also remarkable that all animals prefer green to dry food, though they willingly eat the latter for a change. The stall-feeding of oxen on hay may, however, be attended with some advantages.*

In order to recommend dry feeding in summer, the most unfounded apprehensions have been suggested against feeding on green meat. Thus, it is recommended never to gather the fodder while wet, especially with dew. But, according to my experience, this practice is by no means objectionable, provided only that the fodder be left on the ground till it begins to get hot, without being cocked. It is necessary either to deposit the supply of fodder in a place large enough to admit of its being spread out in a very thin layer, or else only to bring enough for one meal at a time. In wet weather the fodder will not be injured, even though left for some days in breadths upon the ground.

I have never known cattle to be injured by young clover mown before flowering, when it was given to them in moderation. But if it be given to them in very large quantities at a time when they are very eager for green-meat, or if they are allowed access to the place in which it is kept, it may undoubtedly produce indigestion, and its consequence, the *hove* or *blown*. Besides, it is not economical to mow the clover which has put forth its flowers, because in the week during which the flowers come out the plant increases in volume more than it has done for the five weeks preceding. If a field of clover be mown once a fortnight during six weeks, and each crop yields 30 lbs. of fodder, making 90 lbs. in the whole, the same extent of ground will yield 600 lbs. if the crop be mown only once during the six weeks: this has been positively demonstrated by a comparative experiment expressly directed to this subject.

This is one of the main causes which render the produce of a given extent of surface so much greater when the crop is mown than when it is fed off, the plants not being allowed in the latter case to attain their full development. The question as to whether a cow yields a greater quantity of milk when pastured or stall-fed, leaving out of consideration the greater or less extent of ground employed in feeding her, can never be decided in a general manner. The same cow which on pasturage of good quality, but not extraordinary richness, will yield ten quarts of milk per day, may, when stall-fed, yield no more than six quarts, or as much as fourteen quarts, accordingly as her feed is scanty, or substantial and abundant. If, however, the pasturage be of the richest and most abundant description, so that the cattle are not able to consume the whole of it, I believe that a cow will produce more milk upon it than upon the most abundant supply of green food than can be given to her in the stall. Trustworthy persons assure us, that certain cows fed upon the best and most milk-producing pastures, of the low countries, have given from 90 lbs. to 100 lbs. of milk per day at the time of their greatest abundance; and I am not acquainted with any positive instance of stall-fed cows having yielded more than 60 lbs. in the same time.†

There is too much difference between races and individuals, too much irregularity in feeding and maintenance, too much variety in the mode of treating and making use of the products of the cow-house, as well as in their price, to enable us to form any general estimate of the produce, and still less of the pecuniary return of a milch cow. There are positive examples of cows having, under active management, and in the neighborhood of large, populous towns, yielded an annual return of 200 rix-dollars, and others in which the whole produce in milk of a cow has not amounted to three rix-dollars. Undoubtedly there are cases in which the produce of a cow far surpasses the value of the fodder which she has consumed, even if we estimate it at the market price; but this seldom happens under ordinary circumstances. The calculation, however, assumes a different aspect if the fodder be valued, not at the market price, but at what it cost when raised upon the land; and it is in this manner that the valuation must in most cases be conducted; since it is impossible to turn fodder to account in the market. Circumstances are so varied in this respect, that we can add nothing to what we have already said on the subject. The gross profit of a cow, without deducting fodder, pasturage and attendance, or reckoning the value of her dung, varies (if we except cows fed with excessive parsimony, and those most abundantly nourished) between 10 and 30 rix-dollars. The average profit of a cow, in well-managed rural establishments, may be set (taking the average of 40 weeks, or 280 days, during which they are milked at four quarts per day) at 1,120 quarts in all. Now 12 Berlin quarts yield on the average 1 lb. of butter; therefore a cow will yield 93⅓ lbs. of butter per annum.

the same fodder be gathered and consumed as green-meat, the loss is quite inconsiderable. I have made, and likewise induced my friends to make, certain comparative experiments for determining the advantage of consuming fodder in the green rather than in the dry state, and have always found a difference of 1·5 in favor of the former; that is to say, that if 100 lbs. of green clover were sufficient to keep a cow, 125 lbs. of the same clover would be required for that purpose in the dry state. These experiments have never been made with the accuracy which I look for in an experiment whose results are to be considered decisive: but they have been sufficiently multiplied in various places, and by various persons, to give their results a high degree of probability. [*French Trans.*

* Long experience has convinced me that green feeding is well suited to beasts of labor, both horses and oxen, and that the animals, when accustomed to such food, keep up their strength on it much better than on dry fodder. In general, my oxen get very fat upon this kind of food, as soon as the spring-work is over, and they are put to lighter work; and during the laborious interval from harvest-time to the end of October, when they have no rest, excepting on fête-days, and during very heavy rain, the animals sustain their labor with perfect vigor, and preserve their condition; whereas, when I was in the habit of feeding my oxen on dry fodder, they used to enter upon the winter in a very lean and jaded condition.

When my working horses are fed on green-meat, I never give them corn, excepting at the time of their severest labor, and they nevertheless perform their work cheerfully and well.—1815. [*French Trans.*

† I know of instances, rare, it is true, in which 90 lbs. of milk have been obtained from stall-fed cows; in addition, however, to the green-meat, bran was put into their broth. Moreover, these cows were remarkable animals, of large size and excellent breed—altogether a kind of prodigy. [*French Trans.*

A pound of butter, selling for six groschen, this amounts to	23 r.-d.	8 gr.	0 p.
Cheese and the refuse, reckoned at two groschen for 12 quarts	7	18	8
Total	31	2	8

Seven rix-dollars, eight groschen, eight pence, constitute about the whole expense of attendance, cleaning and the dairy, which a cow-keeper will have to pay. Hence 24 rix-dollars is the highest price that should be given for the produce of each cow; but this price would leave no profit, and is therefore realized only now and then in seasons when the price of butter rises very high. But in rural establishments distinguished for the good management of their cows and the goodness of their pastures, the net profit of a cow, even after deducting all expenses of attendance, cleaning, and other accessories, may perhaps be raised to 35 rix-dollars; supposing, however, as already observed, that butter is at a high price.

It has been said that when cows are better fed they yield a larger produce, but that the increase does not counterbalance the additional expense; that, for example, it is not profitable to buy hay for cows. But this depends upon locality; the market price is much higher than that for which I can generally procure hay or fodder to supply its place. When the growth of a scheffel of potatoes costs me at the most two groschen, and a quarter of a scheffel given daily to a cow increases the daily value of her milk by one groschen, I gain two groschen per scheffel by this mode of proceeding. The quantity of food necessary for preserving the life of a cow ought to be given to her under all circumstances, and independently of all considerations of profit; it is the surplus only that produces milk or increases the flesh; and consequently, it is only from this surplus that any profit can be obtained. Hence it follows that the profit resulting from fodder is greater in proportion to the quantity consumed, provided always that this quantity be not greater than the digestive powers are able to convert into blood and other animal matter. We may also conclude from the preceding observations that it is not advantageous to maintain three cows on the fodder which two are able to consume and digest; this, however, is often done, and will continue to be practiced as long as cultivators persevere in reckoning the profit of their cow-house at so much per head of cattle.

The quantity and quality of nourishment best adapted for a milch cow cannot be determined by general rules, but must be varied according to age, breed, and individual peculiarities. For a full-grown cow of average size, the most appropriate quantity appears to be either 18 lbs. of hay, half of which may be replaced by roots, or 80 lbs. of green clover. As to large cows, they may advantageously consume from 25 lbs. to 30 lbs. of dried hay, or from 112 to 140 lbs. of green-meat. Besides this, as much straw may be given to them as they will eat.

Cows are most abundant in milk at the age of six or seven years; and, if they have not calved before their third year, may be maintained in the same state till the twelfth. I do not think it economical to get rid of a cow which is free from defects merely because she is ten years old.

THE DAIRY.

The produce of the dairy is, in this country, the most usual mode of turning horned-cattle to account. Fattening is generally regarded as an accessory. We shall speak first of the dairy, and afterward of the fattening of cattle.

Milk may be disposed of in three ways: first, by selling it as it comes from the cow; secondly, bp converting it into butter; thirdly, by making it into cheese.

The desire to get rid of the trouble of inspecting the dairy and cow-stalls, and to ensure a certain and immediate, though smaller profit, has in many countries induced the majority of great farmers to let their dairies. On almost all the estates in Mecklenburg and on many in Marches, there were formerly cattle-farmers who were there called *Hollanders*, just as dairies in these countries are called *Hollanderies*. The farming was usually arranged according to heads of cattle, and consequently endeavors were solely directed to increase their number, even though pasturage and fodder were continually diminished by the practice; this is, perhaps, the chief cause of the bad state of cattle in those countries. The cultivator ceased to take interest in his milch cows, and *there is nothing like the master's eye for fattening cattle.* The interest of the rural establishment became divided between two branches of economy, the cultivation of produce and the management of cattle, which can never thrive unless they go hand in hand. Unless the farmed herd were very numerous, consisting of 100 head of cattle or more, the advantages which it was necessary to concede to the farmers swallowed up the greater part of the rent.

To save the trouble of inspecting, not only the cows, but likewise the operations of the dairy and the preparation of cheese, which can never well be executed except by careful women, it is much better to sell the milk just as it comes from the cow at a reasonable price to a dairyman. In this way both parties feel a certain security, and take interest in the milch cows and their produce; innumerable difficulties are avoided, and the contractors no longer seek to take advantage of each other, as they always do with regard to quantity of fodder when the farming is arranged according to the number of cattle. I look upon all other modes of farming as inconsistent with a good system of economy.

Great care must be taken that the cows be completely and properly milked, for a scanty produce of the dairy often arises from neglect of this matter. It requires the constant attention of a woman capable of teaching the dairymaids how to go to work. She must, upon the least possible suspicion that a cow has not been well milked, put her own hand to the udder, in order to attest the reality of her doubts, and draw off any milk that may be left in the udder. This attention is required, not for the sake of any additional quantity of milk which may be obtained at the time, but to prevent the loss which would result from diminished lacteal secretion, and to check the progress which carelessness is sure to make, when not promptly corrected.

The four teats must be milked one after the other, even if one of them should not give any milk.

If the udder be foul, it must be washed before milking, because the slightest foulness gives a bad taste to the milk, and may thus bring discredit on the dairy. This point must be carefully attended to, especially when the cows are stall-fed on green-meat.

The water, together with a sponge, or cloth, is contained in covered pails which the dairymaids carry with them, and use as stools to sit upon.

When the dairymaids say that a cow has fallen off in milk, and is scarcely worth the trouble of milking, the milk must be gently warmed, to try if it will curdle: if not, the milking must be continued, in order that the cow may not become accustomed to remain long without giving milk. The milking of every cow must, however, be discontinued about a month before she calves, even though she should yield a quart of milk, otherwise she will be too much exhausted.

Some persons maintain that cows yield a greater quantity the oftener they are milked; but this opinion is not borne out by careful experiments. On the contrary, it has been proved that as much milk is obtained when the cows are milked twice, as when the milking is performed three or four times a day; some persons have, in fact, obtained a greater quantity of milk, but not of such quality as to yield more butter. It is only when the secretion is most rapid, and such that the udder cannot contain all the milk, but allows some of it to drop out spontaneously, that a third milking becomes necessary.

The first portion obtained at each milking is not so rich as the last; but I have never observed so great a difference between the two portions as some persons pretend to have remarked. In places where one part of the milk is sold, and the rest made into butter, these two portions are sometimes separated, the latter only being taken to make butter.

When milk is to be sold fresh, it is important to keep it at a low temperature, not, however, below the freezing point. If the fresh milk be carried to a town a mile or two off, the produce of the evening milk is usually devoted to this purpose, and carried away as soon as drawn, the vessel containing it being immersed in cold, and sometimes in iced water; the carriage is performed during the night, so that the town may be reached early in the morning. At short distances from town, the morning milk may also be added.

This mode of disposing of milk is looked upon as the most advantageous of all. This is, in fact, the case, though not without limitation; for the system involves expense, details, and superintendence, which are not in the power of every farmer. It is certainly the most convenient method, for those who can sell their milk as soon as drawn to a retailer, who takes it away, and is accordingly allowed a profit to recompense him for his trouble. In localities where there is a town-market for fresh milk, there is generally, also, an opportunity of selling fresh butter for the table; and the price of this butter is such as to yield a profit at least equal to that which can be obtained by selling the milk directly. In the country, the quantity of fresh milk which can be sold is but trifling; but there is sometimes an opportunity of selling skimmed milk, whey, and buttermilk, to advantage.

In order to make butter perfectly good and fit for keeping, it is necessary to make one's self acquainted with the process in all its stages.

A good milk-room is an essential condition. It is usually formed under-ground, for the sake of maintaining a proper and equable temperature. The ground is covered with stone slabs, and the false floor thus formed is made to incline to one side, so that the water with which it is continually sprinkled, and that used for cleaning, may drain off into a cistern, and be carried away. The cellar, or milk-store, should have gratings, or apertures, on two opposite sides, so that the air may circulate freely through it. These apertures are generally so disposed that the draught of air may be felt not only in the upper part of the room, but also near the ground. The lower apertures must, however, admit of being shut when the wind is so high as to occasion risk of disturbing the milk-pails placed on the floor. The milk-store must be large enough to admit of the vessels being placed side by side, and not one upon the other; at all events, this latter arrangement is considered disadvantageous in the best managed dairies of Holstein. It is best to place the milk-pails directly on the floor, for it is there that the temperature is most uniform.

A proper temperature is of the greatest importance in causing the milk to cream. If the temperature be too high, the milk turns sour before the cream collects on its surface, and then the cream will not separate. When the temperature is too low, the separation of the cream takes place very slowly. The most suitable temperature is between 12° and 15°. The former is the proper degree of heat for summer, and the latter for winter. To obtain perfectly good butter, we must be very careful not only to keep the vessels and utensils, but also the air of the room perfectly pure. There is no liquid more susceptible in this respect than milk: foreign matter, and exhalations of all kinds, may impart to it a bad taste, an unpleasant smell, and various other defects.

The disposition of milk to become glutinous and stringy often arises from nothing but a vitiated state of the atmosphere, though it may also proceed from some disease in the cow, which may be communicated to the whole mass of the milk. The appearance of a blue color in the milk, or of violet spots on its surface, is in most cases produced by impurities in the air. It is probably a kind of mouldiness, developed on the cream as soon as it comes to the surface. This evil has, after many trials which have come to my knowledge, been cured by airing the cellar well, after it has been fumigated with chlorine or burning sulphur—the various utensils of the dairy being also exposed to this fumigation.

The milk, as soon as drawn, is poured through a sieve into the pails, in order that the cream may collect on its surface. The sieve must not be of woolen or linen cloth, but of hair, and kept in a state of perfect cleanliness.

The vessels in which the milk is put to cream are of metal, earthenware, or wood. Those of metal, especially tin, appear from many trials to be decidedly the best for skimming the milk; but they are too costly for use in large rural establishments. Vessels of clay or porcelain are more easily kept clean than wooden ones, but they are too fragile. Attempts have been made to case them in wood, for the purpose of increasing their solidity. They should be well glazed, as other-

wise the milk, when sour, will penetrate the clay: but glazes containing oxide of lead must be avoided, because sour milk would dissolve a portion of the lead; the quantity thus dissolved would, however, be very small. According to Wistrumb's experiments, the danger arising from this cause is not so great as some persons suppose. Glass and porcelain vessels are too costly, and serve only to make a show. In large dairies, wooden vessels are most commonly used; and when care is taken to clean them properly, and not expose them to the air, they are unexceptionable. Especial care must be taken to prevent their being contaminated by acid fermentation; for this purpose they must be washed, from time to time, with the lye of wood-ashes, and always scoured with water and a brush after being used. These vessels are usually made by coopers; but they are sometimes formed of a single piece of light wood, and flattened at the bottom, in order that they may stand well. The latter are decidedly preferable, both because they have no joinings, and are therefore more easily kept clean, and likewise because they expose a larger surface of liquid to the action of the air.

In all cases, the milk-vessels should be as shallow as possible, in order that the cream may rise quickly to the surface, and be more easily separated from the milk. Deep vessels, of narrow surface, are altogether disadvantageous and defective.

Opinions are divided respecting the proper time for skimming the milk. Some persons allow it to curdle and turn sour, before they skim, thinking to obtain a larger quantity of cream by so doing. But in Holstein, where the art of making butter is most thoroughly understood, the contrary opinion is entertained, and the cream is taken off before the slightest acidity is developed.—The cream is considered ripe when the thrusting of a knife into it no longer causes any milk to rise to the surface.

The latter method is decidedly preferable; for it is a demonstrated fact that acidity not only does not assist the separation of the cream, but, on the contrary, stops it when once begun; and farther, that butter made from sweet cream, besides having a more agreeable flavor when fresh, is better adapted for keeping, and less exposed to become bitter. The slightest degree of acidity causes the mixture of cheesy particles in the cream; the layer to be taken off becomes thicker in consequence, but the quantity of cream is not really increased. It is of great importance to seize the moment when all the cream is collected on the surface, but no acidity is yet apparent. The time at which this effect takes place is subject to considerable variation, according to the state of the atmosphere. At a temperature of ten degrees (centigrade) it may be expected in thirty-six hours; at a higher temperature it takes place in sixteen hours; and, during stormy weather, in twelve or even ten hours. In the Holstein dairies careful persons are set to watch the milk during the night, in order that they may ring up the dairymaids as soon as the precise time is arrived, this they ascertain by the signs already spoken of.

The cream is taken off by means of a wooden spoon shaped like a shovel.

The butter should, if possible, be made as soon as the cream is taken off. In well-managed dairies, only the portions of milk obtained in one day are mixed together. In small establishments, where butter is made only once in two or three days, the cream must be kept in earthen vessels, and as fresh as possible.

Butter is separated from the surplus of cream with which it is mixed by a mechanical movement, produced in various ways. There are two sorts of *churns*: one high, narrow, and fixed; the other shaped like a barrel. The latter either turns upon a fixed axis, having wooden vanes attached to it; or the barrel is fixed, and the axis with its vanes turns within it, being moved by a handle. Barrel churns have been extolled above their real merits. In order to estimate their value properly, and in general to form an idea of the points to be attended to in making it, it is necessary to know how this substance is formed and separated.

The fatty part of milk is not actual butter; the latter substance is formed by the action of the air upon the cream—in fact, by the absorption of oxygen. For this reason, the air must have free access to the cream, and be renewed as often as possible in the vessels in which it is stirred. It has been shown, by direct experiment, that oxygen is the principle most actively concerned in producing the change; for it has been found that the butter appears more quickly in proportion as the air is more charged with oxygen, and that when that substance is not present the formation of butter does not take place.

In this respect the high, narrow, fixed churns have the advantage over those which are barrel-shaped, because the latter must be closed, and the oxygen contained in the confined portion of air is soon consumed; whereas fixed churns allow a sufficient quantity of air to enter, and moreover the air is constantly renewed in them by the agitation which effects the separation of the butter.

But these pump-churns are likewise preferable in another point of view; the oily particles, hardened by the air and transformed into butter, still swim in the liquid in a state of minute division, and must be collected by agitation into larger masses. Now, in churns which turn upon an axis, the motion is not sufficiently powerful; for, although the whole of the liquid is thrown into a revolving motion, it is not beaten and stirred up thoroughly as it ought to be. But in fixed churns the beating up and down produces a continual displacement of the milky particles, and thus brings the buttery portions into contact. The long, fixed churns have also the advantage of being more easily cleaned than those which revolve.

But as the beating or pumping motion is laborious when performed by unassisted manual strength, particularly with large quantities of liquid, various mechanical contrivances have been devised for diminishing the labor: they consist, for the most part, in attaching the rammer, by a movable connection, to the arm of a lever. The butter is generally stirred in two churns at once, so that the rod descends in the one at the same time that it rises in the other. Motion is given to the beam either by a heavy hammer, which is moved backward and forward by two men, and, when once in motion, goes on without difficulty, or by means of a wheel whose circumference is loaded. In the very largest dairies, the machine is set in motion by horses or oxen. This method is, moreover, advantageous, inasmuch as it gives regularity to the motion, and then the butter is formed in a better manner than when the motion is sometimes fast and sometimes slow.

In the preparation of butter, a point of equal importance with the preceding is the maintenance of a proper temperature. When the cream is too cold, the buttery particles become too hard, and not glutinous enough to stick together; too high a temperature, on the contrary, makes the butter very soft, and then the clots become divided during agitation, and mix again with the milk. If the cream be too cold, the churn must be heated either by putting it in a warm place, or mixing a little warm water with the cream; when, on the other hand, the temperature is too high, it becomes necessary to cool the churn by placing it in cold water, or, if possible, in ice.

There are, however, other causes of difficulty in the preparation of butter. The milk of cows in a very advanced state of pregnancy is not easily converted into butter. The process may sometimes be facilitated by the addition of a little salt; no injury will be done by the slight degree of saltness thus imparted to the buttermilk. It is also said that a piece of alum put into the strainer produces a good effect. Much praise has been bestowed upon a powder composed of dried *sorrel-leaves, horehound, yarrow*, and *nettle;* three handfuls of each, and half a pound of flowers of sulphur. A handful mixed with a pound of vinegar made from beer is given to each cow three times a day. The sulphur and beer-vinegar are the really useful constituents of this mixture.—Sugar, ashes, or soap, falling into the cream, prevent the butter from forming. The common people attribute this accident to witchcraft, and resort to all sorts of superstitious ceremonies to obviate it as well as other defects in the milk.

When butter is to be colored, the coloring matter must be placed in the churn. With us, the coloring is usually given with carrot-juice. In Holland, they use *marigolds*, which for this purpose they gather fresh; they then put them into a stone vessel, press them together, cover them completely, and keep them in cellars. A deeper color is given by another material; an ounce of which, of the size of a pea, is put into thirty pounds of cream the evening before the butter is made.

Butter, as soon as made, should be separated from its milky residue, for the latter being much disposed to ferment, would infect the butter and give it a bad taste. In Holstein, butter is not washed, but very carefully kneaded, washing being considered injurious. For my part, I prefer washing, provided the butter be well worked and kneaded afterward. No moisture should be allowed to remain in it: the portion which cannot be got rid of is absorbed by common salt, and can no longer either ferment or cause fermentation. It is probably for this reason that butter for keeping must always be salted: the less butter is cleaned the more does it require salting. A pound of salt is added to five, ten, or twenty pounds of butter.

The principal cause of butter acquiring a bad taste and smell after a while, is undoubtedly that a certain portion of cheesy matter remains in it, and enters into a kind of putrefaction. The less there is of this matter, the longer will the butter keep. In many places, badly cleaned butter is melted to make it keep longer, the cheesy parts being separated by this fusion: but butter thus melted never preserves the agreeable flavor of fresh butter, and can only be used for culinary purposes.

When butter is kept in tubs or earthen vessels, it must be packed as closely as possible, and no interstices or vacant spaces left, for the butter quickly spoils around these interstices, and the evil spreads through the whole tub. In large establishments, it is considered essential that a tub be filled with butter made all in one day.

Skimmed milk is used in various ways; it is sometimes mixed with buttermilk for human food; sometimes used in making bread; sometimes to make cheese; or, lastly, to feed pigs. These animals, as we shall hereafter see, are also fed upon whey

The whole of the milk is sometimes used, unskimmed, in making butter; and many persons consider this method advantageous, especially when only the richer half of the milk is used. But such butter will not keep long, and it is much less rich than common butter, because it contains a larger quantity of cheesy matter.

Cheese-Making.

The preparation of cheese of first-rate quality involves a greater number of details, and requires more attention, than that of butter. But it is in many cases much more profitable; indeed, the profit of the dairy is often doubled by it. In former times, all our good cheese was brought from foreign countries, and had to pass through several hands, so that we were obliged to purchase it at a price considerably above prime cost. In undertaking the making of cheese, however, we must not forget that good, sweet cheese requires to be kept for a year, or even a year and a half, before it becomes fit for sale; and consequently that it employs a capital, the interest of which must be paid, as well as the rent of store-houses for keeping the cheese; moreover, there are but few rural establishments which have this capital at disposal.

There is an almost endless variety in the modes of preparing cheese, and this variety is the principal cause of the differences of taste, smell, solidity and color, which cheese exhibits. It is true that the kind of pasturage on which the cattle are fed, the manner in which they live, and the climate, may have some effect on the quality of cheese, so that they may vary in taste, even when prepared in the same manner; indeed, even in countries where cheese is made in large quantities, one locality is admitted to have the advantage in some respects, while in others, the superiority is awarded to cheese made elsewhere. This difference is almost universally attributed to the nature of the pastures, and to certain plants which grow upon them. But it is also certain that the most trifling difference in the mode of preparation will give character which connoisseurs are sure to detect; and in localities famous for their cheese, the women who make it have peculiar modes of proceeding, which they refuse to communicate to others. Such differences are, however, inappreciable, excepting to very refined palates.

When connoisseurs in cheese are accustomed to particular sorts, and require that all imitations shall have exactly the same flavor, and other characters, as the originals, it becomes difficult to satisfy them; but such pretensions are founded rather on obstinacy than on real superiority of taste. There is every reason to believe that we are capable of making cheese which, even if not pre-

cisely similar to the best Cheshire, may nevertheless be superior to it in flavor; and if we can only succeed in giving to our cheese a quality proportionate to its price, we shall not fail of obtaining a market for it. We must, however, especially in commencing the undertaking, endeavor to approach as closely as possible to some kind of cheese in high estimation, either for taste, form, or internal appearance.

The innumerable varieties of cheese are classified according to the following properties:—

1. With regard to richness, we have,

(*a*). *Very rich* cheese, made from morning milk as it comes from the cows, and the cream of the evening milking.

(*b*). *Rich* cheese, made from milk just as it comes from the cows.

(*c*). *Poor* cheese, made with skimmed milk.

But there are degrees of richness according to the quantity of cream used for the first variety, and the quantity taken off the milk from which the third is prepared.

2. A distinction is made between *sweet* and *sour-milk* cheese, accordingly as the milk and cream from which they are made are used fresh, or allowed to acquire a certain degree of acidity.

3. Another distinction is between pressed and unpressed cheese. It is only by pressure that cheese can be separated from all the whey that is mixed with it. Now the whey, by fermenting, imparts to the cheese a peculiar pungency, and a disposition to alter its consistence, and, especially in a damp atmosphere, to melt, and be converted into a kind of viscous liquid. Hence, the more carefully the raw material is worked, and the oftener the cheese is pressed to get rid of the whey, the sweeter and better adapted for keeping will it become. The sweetness of Gloucester and Cheshire cheese arises chiefly from the repeated and careful working bestowed upon it, and the strong pressure to which it is exposed for expelling the whey. But cheese thus prepared becomes almost as tough as leather, unless it contains an abundance of fatty particles.

Unpressed cheese must be consumed soon after it is made, or it will quickly attain a state of putrid fermentation. When this happens, the cheese is worked anew, put under the press, and mixed with cream and butter; the progress of putrefaction is checked by wrapping it in cloths moistened with beer containing a large quantity of hops, or with wine; a quantity of hops, or other aromatic substances, is placed between two of the cheeses, and the drying is repeated. It is in this manner that the strong, pungent cheeses so much esteemed by some persons as a stimulus to the appetite, are prepared.

4. Cheese is also distinguished according to the manner in which the milk is curdled, and the substances employed for producing this effect.

Milk is curdled either after being warmed, or at its natural temperature (26° *centigrade*), or after cooling.

The warmer the milk, the more readily does it curdle, the quantity and the pressure to which it is subjected being the same. But if the milk be too warm, and curdle too quickly, the cheese will be hard. The fineness and delicacy of the cheese-paste are greater in proportion to the freshness of the milk. Cheese made from milk which has curdled slowly, does not become ripe enough for sale so quickly as that which has been made to curdle rapidly.

Coagulation may be effected by simply warming the milk when it has acquired a slight degree of acidity; but this method is adopted only with sour-milk cheese. It is known that all acids coagulate milk. Mineral acids are often used for this purpose, especially the hydrochloric; the effect is also brought about by means of vinegar, and different vegetable substances, containing an acid principle, or tannin, such as tamarinds, sour fruits, oak, willow, and alder bark. The *yellow bed-straw*, or *cheese-rennet* (*Galium verum*), has been long recommended as an excellent substance for curdling milk: this property has, however, been lately called in question.

But the rennet most generally used is the stomach of a sucking-calf, and the substances contained in it, after it has been well cleaned. The last of the four stomachs is the one used for this purpose.

The modes of preparing and keeping these calf-stomachs vary to a great extent; many persons maintain that the slightest difference in the preparation has great influence on the nature of the cheese. Celebrated cheese-makers, therefore, often make a secret of their mode of preparing the rennet. Marshall, in his description of the rural economy of Gloucestershire and the southern counties, has detailed various processes adopted for preparing the rennets in those counties of England most celebrated for their cheese, viz., Gloucestershire and Cheshire, in which he prolonged his stay, for the purpose of acquiring a knowledge of these processes: this part of his writings deserves to be translated. I do not think, however, that slight differences in the rennet have so great an influence on the quality of cheese, and Marshall himself seems to have come round to this opinion.

The following is one of the processes most frequently adopted: The stomach of a sucking-calf is opened, and the curdled milk taken out: the latter is cleaned, particularly from hairs which may be found in it, and washed with cold water till it becomes quite white: it is then squeezed in a cloth properly adapted for drying it, spread out, and carefully rubbed up with salt. Then the stomach is also washed in cold water, rubbed with salt, and the previous preparation enclosed in it; the whole is put into a pot, and covered with salt. As many stomachs as can be collected in a month are put together. The rennets thus prepared must remain for a year in the vessels before they are used; and when they are to be used, one of the vessels is opened, and emptied, and its contents carefully pounded. The yolks of three fresh eggs and a small glass of good cream are then added. It is usual, after mixing the whole well together, to throw in a small quantity of spice, flour, and seed of nutmeg, a clove, and a little powdered saffron. The whole is then again put into the bag, and hung up in a proper place. Next a strong mixture is prepared, boiled, and left at rest as long as required; 8½ oz. of rennet taken out of the bag are put into it, four or five walnut leaves are also put into it, and the whole left at rest for a fortnight.

Another mode of proceeding is to take the stomach of a young calf, together with the coagulated milk contained in it, and carefully wash the latter. The stomach is then also carefully washed,

and left in salt for three days. Five or six eggs are then boiled in water till they become hard cut up small, and mixed with the curdled milk: the whole is then replaced in the salted stomach, hung up in the smoke for three weeks, and afterward in the open air. When it is to be used, a piece is cut off, mixed with a little milk, and poured into that which is to be curdled.

A third process consists in taking three or four stomachs of calves, removing the coagulated milk, washing and kneading it with a handful of barley-meal and an equal quantity of new bread and salt. The stomachs themselves are not salted: they are merely scraped a little, and the matter thus separated from them joined with the mixture just described. The whole is hen placed in a stove or earthen-ware vessel, with a little salt above and below it, and kept in a cool place.*

I have no actual experience in the preparation of cheese, but on the other hand, I have the most convincing proofs that in this country, even with the milk of stall-fed cows, and during winter, the most celebrated cheese may be imitated so closely, that the difference shall be inappreciable even to the practiced taste of a connoisseur. And even if cheese thus prepared should be somewhat different from that which we seek to imitate, it would not on that account be necessarily worse; it might indeed be superior. But we must not attempt to make rich cheese with skimmed milk, sweet cheese without pressing out the whey, soft cheese without paying great attention to the temperature, or generally good cheese without observing the strictest cleanliness. We must not allow ourselves to be disgusted with a single failure; and to judge of all the cheeses that are fit for keeping, it is necessary to wait for the time when they become eatable, and meanwhile to adopt the best possible means of preserving them, and among these an airy cheese-cellar is absolutely necessary. As all these matters are left to the management of women, it is necessary that the superintendent take a lively interest in the success of the undertaking; without this it will rarely turn out well.†

FATTENING OF HORNED-CATTLE.

In countries where grain is cultivated in large quantities, there exists a deep-rooted opinion that the fattening of horned-cattle is positively disadvantageous, excepting in large brandy distilleries. This opinion is, however, often unfounded. Local circumstances may alter the relative value of fattening, according to the results afforded by maintaining cattle for other purposes.

In calculations which profess to show that this branch of economy is unprofitable, the question is not correctly stated; the food given to cattle being estimated at the market price, instead of at the cost of production. Every one knows that the maintenance of cattle is indispensable to grain cultivation: the influence of this maintenance on the produce of grain has, indeed, been developed in several parts of this work. Moreover, in the greater number of cases, we cannot dispense with horned-cattle. The real question at issue, therefore, is, which kind of cattle is to be preferred, and, with regard to horned-cattle in particular, whether the quantity of fodder and pasturage devoted to them can be more advantageously consumed by milch cows or fattened oxen.

This question merges into the two following:—

(*a*). What is the proportion between the quantity of fodder consumed by a milch cow during the whole year, and that which an ox consumes in the time required for fattening him?

(*b*). What is the profit of an ox during the time that he is fattening, and that of a milch cow during the whole year?

We have already spoken of the quantity of fodder consumed by a milch cow, and the differences observed with regard to this matter. That required for an ox put up to fatten likewise varies according to the size of the animal, and the quantity of flesh and fat which we wish to give him. But it is perhaps easier to fix a tariff for each particular case of fattening than for those

* Instructions on the making of various kinds of cheese will be found in the following works;—Of Swiss cheese in the third part of Witte's work "On the breed of German Horned-Cattle:" [see also the excellent work entitled, "Des Fruitières," by Ch. Lullin.—*French Trans.*] of Cheshire cheese in the "Archiv der Agricultur Chenie of Hermbstadt:" of Lamburg cheese in the "Annalen des Ackerbaues," bb. xi. s. 632: of various kinds in the "Encyclopædia of Krunitz, vol. xxxv.: see also Voss, "Anweisung-Rahm-und-Fett-Käse welche dem besten Engbahen und Hollandeschen gleich Kommen zu bereiter." Altona, 1807. "Vollständige, und deutliche Anweisung zur Bereitung des beruhmten Englischen Chester Käses." Pirna, 1803.—Twamley—"Anweisung Englische Käse zu machen, aus dem Englischen ubersetzt mit Anmerkungen"—Frankfurt am Main, 1787. [*Thaër.*

In Switzerland there are several kinds of cheese very different from one another. The most esteemed of all is certainly the Gruyères cheese; most of the others resemble it more or less, the differences arising rather from the nature of the pasturage than the mode of preparation. The Urseren and Bellelay cheeses have quite a different taste. In the canton of Glavis they make a kind of cheese containing aromatic herbs; it is very high-flavored, and much esteemed by some persons. Its local name is *shaapzigner*; a name which implies that it is not a cheese properly so called, but a *seret*. [*French Trans.*

† In Switzerland and Italy, cheese-making is not entrusted to women; they are rarely, indeed, employed to milk the cows, especially for large dairies. There is no doubt, however, that they would be very well adapted for both these duties if they were accustomed from their youth to the necessary regularity and exactness. In the countries just mentioned, the cheese-maker is one of the most important persons on the farm, for upon his skill and attention mainly depend the success and quality of the cheese, the produce of which forms one of the most important sources of income. [*French Trans.*

Our author might have noticed in this place, that another product called *serac* or *seret*, not so rich as cheese, but nevertheless constituting a useful article of food, is obtained after the fabrication of cheese, by boiling the whey and adding fresh rennet. In the neighborhood of towns, this substance is usually sold fresh, and appears in various forms on the tables of the rich. When salted like cheese it keeps for a long time; and though not, perhaps, so good as cheese, is still a wholesome kind of nutriment, and within reach of the poor people. The quantity of whey is, however, diminished by this preparation, and I am not sure but that in the greater number of cases, when the cost of labor and other expenses have been deducted from the value of *seret*, it may not be more advantageous to have the whey consumed by pigs, just as it is obtained after cheese-making.

The author might also have spoken of the preparation of milk-sugar, which, by the reöpening of maritime communication, has fortunately been reduced to the small quantities required for pharmaceutical purposes. [*French Trans.*

which relate to the management of milch cows. In localities where fattening is practiced to a considerable extent, the daily allowance which ought to be given to an ox of a certain breed is determined with tolerable accuracy. Hence, in these countries it is usual to fix the weekly price which a butcher or cattle-dealer is to pay for the feeding of an ox: this price, however, is subject to certain modifications according to circumstances of place and time. Thus it is easy to calculate beforehand, and resolve the question for one's self: the result shows that fodder is often better repaid by fattened oxen than by milch cows, especially when the short time of fattening is compared with the maintenance of a cow for the whole year, and the care of the dairy; to this we must add, that the fattening of oxen during winter takes place at a season when labor is abundant, while the maintenance of cows continues during summer, when laborers are often difficult to obtain. In many cases, also, it must not be forgotten, the capital devoted to fatten oxen returns in four or five months, while that expended on milch cows is always floating.

On the average we may reckon that an ox, while fattening, consumes almost as much fodder as will suffice for a cow during the whole year; but at the same time the dung yielded by an ox while fattening is equal to that which a cow furnishes in an entire year, and perhaps of better quality; besides, this dung is obtained at a time when it can be easily carted.

Even if it be not thought advantageous to make fattening the basis of the economy of live stock, it may, nevertheless, be very useful as an accessory branch. When the whole economy of fattening is once thoroughly understood and organized, it will always be much easier to regulate the number of animals put up to fatten, according to the annual quantity of fodder, than that of any other description of cattle. We must be careful not to increase the number of animals maintained beyond that which we are certain of being able to support, even in bad years; the excess of fodder obtained in good years may be employed in fattening cattle, which are always easily procured from without, even if we have none of our own that we wish to improve. It is commonly more profitable to sell fat than lean cattle.

Whoever would undertake the fattening of a large number of cattle, must endeavor to acquire experience in the knowledge and valuation of them, and of all that relates to this branch of commerce, or at least must avail himself of the direction of a well-informed and intelligent man. The choice and valuation of cattle require a certain practice of eye, and still more a certain tact of hand, which cannot well be acquired without long practice. It would, therefore, be useless to describe them here. They can only be obtained by actual inspection and comparison of a large number of cattle. Great facility in valuing cattle, and certainly in buying and selling, as well as in the whole process of fattening, are obtained by the use of a machine for weighing living animals. Such an instrument is neither expensive nor complicated. A box, formed of boards joined together, and of sufficient length and breadth to allow an ox to stand upright in it, is suspended by a chain from the shorter arm of a balance-beam. There is a door for the animal to enter; and on the other side a rack, in which a little hay is put to induce him to go in. The box rests firmly on the ground. The other arm of the balance-beam, which may be of wood, is ten times longer; a dish is suspended from it for holding weights. The equilibrium should be established by means of this dish in such a manner that the addition of the smallest weight shall raise the box when empty. The longer arm of the beam being ten times as long as the shorter, any weight placed in the dish produces a tenfold effect upon that which is in the box: the tenth of a pound in the former will support a pound in the latter, and one pound will support ten. The weight of the beast is ascertained as soon as the box begins to move in the slightest possible degree; it must not be lifted for fear of frightening the animal. Such an instrument may be placed in a stall, the pivots on which the beam turns being suspended between two beams: it may also be put up in a yard, but it will then require a stand to support it. A machine of this description is also very useful for weighing fodder.

Some persons profess to determine the weight of a beast by the dimensions of particular parts, and the use of certain arithmetical formulæ. But even supposing this method to be applicable, with tolerable certainty, to the greater number of cases, the rules in question can be adapted to a particular race only, and one that is well fixed; so that every breed must require distinct formulæ practically determined. That such is really the case has long been known in England. In the actual state of things it would be very hazardous to rely on such data.

According to the experience of the English, the weight of an animal in butchers' meat may be estimated with tolerable accuracy by its weight while alive.

By weight in butchers' meat, we mean that which a beast weighs when hung up, with his head, fore-legs, entrails and suet removed—the weight in net flesh, as it is called. But for this purpose the health and condition of the animals must be taken into consideration. For an ox not absolutely lean, but still not fattened, Procter Anderdon gives the following rule:—Take half the weight of the animal while alive, add to it four-sevenths of the whole, and divide the sum by two; the quotient will be the weight of net flesh. For example, suppose a live ox to weigh 700 lbs.—

Half of 700 lbs	350 lbs.
Four-sevenths of 700 lbs	400
	750 lbs.
Half sum	375 lbs.

In this case 20 lbs. would yield 10 5-7 lbs. But when oxen are a little fatter it has been found that 20 lbs. commonly yield 11 lbs. and when they are completely fattened 12 or 12½ lbs; for, as an ox gets fatter, the proportion of his flesh to the refuse becomes greater.

Finally, in fattening cattle, the greatest regularity must be observed in distributing the food, cleanliness, &c.; matters of which I shall speak under the head of each description of fattening. In this place I content myself with recommending that no one undertake the fattening of a large number of cattle, unless he can have an eye to them himself; or, at the least, unless

he can obtain the services of a man deserving of the most implicit confidence, and thoroughly devoted to this branch of economy.

Summer fattening is divided into pasturage and stall-feeding on green-meat. The former system requires very rich pastures; which, for this reason, are called *fattening-pastures*. There is a dispute in England respecting these pastures, whether it is better to place the cattle on the whole of the grazing land devoted to the herd, leaving them at liberty to roam over it; or to divide the pasturage into a number of small enclosures, admit only a few animals to each, and use them alternately, so as to leave time for the grass to grow again.* Most persons are in favor of the latter method, which is supported by the strongest reasons. In the low countries of the Lower Elbe, it is an established custom in most localities to have the meadows grazed and mown alternately. In spring, one enclosure or piece of meadow-land, surrounded by ditches, is devoted to the cattle, while another is reserved for hay-making. After the crop has been taken from the latter, cattle are turned in upon it; while the former is left to produce grass for mowing. In other cases one piece of land is used exclusively for pasturage, but the cattle have likewise the benefit of the other after the hay-crop; the latter then serves as a supplement to the former toward the end of summer, when vegetation begins to slacken.

In these low countries, an acre per day is the estimated quantity of land for a large ox of the native breed; which will attain the weight of 1000 lbs., net flesh. This acre contains 450 perches each, 16 feet square, and is equal to 3¼ of our acres; but the same extent of ground suffices for 1½ small oxen of the Jutland breed. It is usually reckoned that the fattening of a large ox yields a profit of 8 Frederics-d'or, and that of a small one 6: the latter is regarded as the more advantageous. It is not uncommon to find one or two horses among horned-cattle; sometimes, also, sheep of the low country breed: the latter crop the finer herbage, the former that which is coarser and grows on the richest spots. This method is considered economical.

Thistles soon spring up vigorously on pastures of this description: they are not eaten while young by the cattle, and they prevent the grass which grows around them from being cropped. Every careful farmer will, therefore, mow them down: when withered and half dry, cattle willingly eat them.

It is of great importance to remove everything which can disturb the cattle while grazing. No one should therefore be allowed to enter the enclosures; and particular care must be taken to keep dogs out.

When there are no trees in the enclosures, stakes with notched edges are fixed in the ground, for the cattle to rub themselves against. Good and convenient watering places must be provided. Sometimes, however, it becomes necessary to draw water from wells, and give it to the cattle in troughs.

Fattening cattle may also be pastured by the tether, on fields where fodder-plants are cultivated: the mode of proceeding is the same as that already described for cows.

Green-feeding in the stall is not usually adopted for fattening cattle. I am, however, acquainted with various cases in which it has been successfully practiced. Oxen will get very fat on green clover, if they are plentifully supplied with it. But an ox eats from 200 to 250 lbs. of green clover per day, in addition to good straw, which he will readily eat between his meals. If he can be partly fed on hay or dry clover, the green-feeding will, doubtless, be still more profitable to him: this method diminishes the excessive relaxation of the bowels which otherwise ensues. A mash, containing oil-cake or a little ground corn, has been found particularly useful, especially toward the end of the fattening.

This summer fattening on green-meat in the stall can, however, be advantageous in a small number of cases only, because at the season of its termination there are usually a large number of pasture-fattened cattle in the market. The clover intended for fattening the cattle may be more advantageously made into hay, and used for winter feeding.

One method of fattening cattle in the stall, both in summer and winter, is to feed them on the refuse of the brandy distillery. In countries where the quantity of meat consumed is but small, this mode of fattening is almost the only one adopted; it renders the distillation of brandy a rural rather than a town occupation; because the townsman cannot pursue it to so much advantage, for want of straw, and the means which the cultivator possesses of employing the dung. When the cultivator begins to devote himself to this branch of economy with the same degree of industry as the townsman, and the Government permits the exercise of each description of industry in the locality best adapted to it, the town distilleries are unable to compete with those in the country. It is said that the refuse of 10 metzen of grain which has passed through the still, with cut straw and a little hay, affords, on the average, sufficient daily nourishment for fattening an ox. Where the quantity distilled amounts to 6 scheffels per day, 9 3-5 or even 10 oxen per day may, therefore, be put to fatten. If the oxen be sold at the end of 20 weeks at a profit of 20 rix-dollars per head, or 200 rix-dollars for the whole, and the quantity of food consumed in this time is 840 scheffels, the cost of the brandy is diminished by 5 groschen 8 deniers per scheffel. The farmer can very well give the hay and straw for the sake of the dung: but the townsman cannot. The profit, however, often amounts to more than 30 rix-dollars: and it is not uncommon to pay from 1 rix-dollar 8 groschen to 1 rix-dollar 12 groschen per week for the feed of an ox.

The refuse of the still is usually poured upon cut straw, to be given to the oxen, which therefore receive part of their food in the liquid form. They are said to fatten most quickly when this is given to them warm. Oxen thus fed are in a constant sweat, and hence it becomes necessary to protect them from wind coming through cracks, which would check the perspiration. Cattle would not long preserve their health on such diet: but they can support it during the fattening time.

The farther, however, the production of alcohol is carried by complete vinous fermentation, the more does the refuse of the distillation lose of its nutritive principles; so that cattle often fatten better, the less completely the operations of the still are conducted. The Brabançons, although

* See the "Annalen des Ackerbaues," No. 112, A.

they know the superiority of distilleries conducted on the Dutch system, still keep to their old method, notwithstanding its defects, for the sake of their cattle. In the neighborhood of the Rhine, the distillation of brandy from grain is no longer found advantageous, either on account of the rise in the price of grain, or of the competition of brandy made from wine-lees; the distillation from grain is, however, continued, because the manure which it affords renders it one of the pillars of Agriculture.

The residue of other kinds of raw material ought to be proportionate to the quantity of brandy which they yield. If, for example, 3½ scheffels of potatoes yield as much brandy as 1 scheffel of rye, the residue of the latter preparation will contain the same proportion of nutritive matter. Some persons, however, say that they have found it less substantial.

In fattening on distillers' refuse, as well as in every other mode of stall-fattening, care must be taken to maintain a uniform, and in winter a somewhat high temperature. Light may and must be intercepted, for just in proportion as it keeps up the health of cattle so does darkness accelerate the attainment of the required degree of fatness, which is in reality a kind of disease: this effect is due partly to physical action, and partly to the repose and inclination to sleep which darkness produces.

Cleanliness and a good supply of litter are highly beneficial. The cattle then lie down during the greater part of the day, only rising to eat. Keeping the skin clean, and currying, visibly accelerate fattening; the animals plainly manifest the agreeable sensation which the operation affords to them. The old hair falls off as soon as the fat begins to form, and new is produced. At this time in particular, currying must not be neglected; the trouble which it occasions will be amply repaid. Though the advantage of this treatment to milch cows may yet be doubtful, there is no question about the benefit which it confers on fatted cattle. The instrument used for the purpose is a wooden comb, fitted with a handle to facilitate its use.

The utmost regularity must be observed in the hours of feeding, and the quantity of food given at each meal. Animals acquire a most exact knowledge of time. This is remarkably conspicuous in old beasts of draught, which, when the proper hour of rest arrives, refuse to work and want to go to the stall, or the field in which they graze. Stalled cattle become restless when their feeding time is not punctually observed, though very quiet before the time arrives. They also know the quantity usually given to them: when they have received and eaten it, they go to rest; but if they have not had their full allowance, they continue restless. The repose and contentment, the happy freedom from anxiety, arising from the certainty of receiving their food in proper time and measure, contribute so much to the fattening of cattle, that a much more plentiful supply, given irregularly, cannot make up for the want of order. The hours for feeding and the quantity of food may be variously regulated: but a system once adopted should be steadily adhered to.

In countries where hay is abundant, it is sometimes used as the sole winter food. An ox, brought to the weight of 700 or 750 lbs., and receiving 40 lbs. of good hay daily, increases in weight 2 lbs. per day, or 14 lbs. per week. If a pound of meat be worth 2 groschen, the ox increases in value at the rate of 1 rix-dollar 8 groschen per week: hence, 1 quintal (110 lbs.) of hay will procure a return of 12 groschen, the value of the dung being set against that of straw and attendance. Hence, in all cases in which this price of hay is such as to satisfy the cultivator, fattening will not be so inconsistent with good management as some persons assert.

But various experiments made in this country seem to show, that if, instead of 30 lbs. of hay, an ox receive 60 lbs. of potatoes and 10 pounds of hay per week, he will improve in condition, and increase sensibly in weight and fatness. As, however, he will eat a little more straw, we will suppose that the profit of this mode of fattening is not greater than the preceding. The value of 70 lbs. of hay per week amounts to 7 groschen. The 420 lbs. of potatoes which he receives per week will, therefore, be paid for at the rate of 21 groschen and 1 scheffel, or 100 lbs. of potatoes will be consumed, at the price of 5 groschen. The potatoes given to the ox are watery, and of inferior quality: the price put upon them is therefore amply sufficient.

If the fattening continue for sixteen weeks, an ox will gain 224 lbs. of meat and fat, and increase in value by 18 rix-dollars. If this ox be fattened upon hay alone, he will consume 4,480 lbs.; if with potatoes, he will require 1,120 lbs. of hay, and 67 scheffels 20 lbs. of potatoes.

If the fattening continue for twenty weeks, the ox will gain 280 lbs. of flesh and fat, and his value will be increased by 38 rix-dollars 8 groschen. His consumption during the whole time will be 5,600 lbs. of hay, if he be fed on hay alone; or 84 scheffels of potatoes and 1,400 lbs. of hay, if potatoes be also given to him.

I say nothing in this place of other kinds of succulent fodder, such as cabbages, turnips, mangel-wurzel, and carrots. These plants, though common in England, are but rarely used for fattening cattle in this country. Cattle are never fattened in England on mangel-wurzel; and notwithstanding the utility of this plant to milch cows, I doubt whether an ox could bear it long enough in the quantity which would be necessary if he were fattened on it alone. I observed, last autumn, that cows fed upon this vegetable, without any addition excepting an abundance of straw, were attacked with indigestion, and ultimately refused it. The large quantity of saccharine matter which beet contains, seems to be advantageous to the animal body in certain states only;* but when united with the more farinaceous potato, it is wholesome. Its value, relatively to that of other produce, is that which I have assigned to it in a previous portion of this work.

In this country, raw potatoes intended for cattle are cut into slices with the root-cutting machine. I am not acquainted from personal observation with any case in which cattle have been fattened

* I have observed the same thing to happen with sheep subjected to the trial. At first they ate the mangel-wurzel with the greatest avidity, and to such an excess that they were attacked with indigestion and ultimately refused the food. I then put another lot on half-dry fodder and half mangel-wurzel, and they certainly fattened more than any of the rest. On my establishment oxen have been successfully fattened on 28 lbs. (18 oz. each) of aftergrass and 50 lbs. of mangel-wurzel per day. As a fattening diet, I consider beet of higher value than our author here assigns to it. [*French Trans.*

on potatoes, either boiled or steamed, though in many brandy distilleries there are arrangements for preparing them in the last-mentioned way, and they are used for fattening pigs. I cannot, therefore, decide upon the comparative advantages of boiling. If the cattle are fed with 10 lbs. of hay per day, in addition to the potatoes, and are likewise supplied with good straw, or if the hay and straw be cut up together, there will be no danger of hurtful diarrhœa; but when they are fed on potatoes alone, I think that diarrhœa is to be apprehended, and consequently that it is better to boil the potatoes.

As matters are arranged in this country, it can rarely be advantageous in an economical point of view to fatten cattle with grain, or other farinaceous food—such for example as linseed, although it greatly accelerates the fattening: but grain may be used with advantage as an extra diet, and to complete the fattening of very large beasts. The addition of a metzen of ground barley doubtless also expedites the fattening, and may be advantageous in this respect. With regard to other kinds of fodder, especially those which remain succulent, we must not at first venture to give the cattle the full allowance ultimately intended for them: they must be gradually accustomed to it, or they will be liable to indigestion: this precaution is the more necessary in proportion as the cattle are leaner when first stalled. But the most experienced feeders in England say that it is necessary to begin with the most substantial kinds of food, in order to enlarge the secreting vessels, or rather to stimulate and bring them to a higher degree of activity. This is effected chiefly by means of farinaceous and easily digested food; a mash of this description is very useful for the first week or fortnight, during which time a smaller quantity of other food is given. Afterward, when the cattle have attained a certain degree of fatness, they become gradually less inclined to eat, and do not consume so much as before: they therefore continue in the same state. If it be desired to raise them to a higher condition, their food must be changed to something of a more succulent character, containing a larger quantity of nutriment under a smaller bulk; and if very fat meat be required, grain will often be found advantageous.

Oil-cake, especially that made from linseed, may also be profitably used in fattening cattle: it may either be ground and spread upon the fodder, or mixed up in the mash.

When a single beast continues sensibly behind the rest, it will not be advantageous to force him into condition. The attainment of this object might doubtless be effected in some instances by the use of very substantial and easily digested fodder. But the profit would rarely pay the expense, and, therefore, it is better to get rid of the animal as soon as possible, and at any price.

Horned-cattle fatten most readily at the age of 7 or 8 years. Younger animals not arrived at their full growth may indeed grow very fat, and furnish delicate and savory meat: but they always require more fodder and longer time. Old beasts do not fatten so easily: if, however, their organs of mastication are strong enough to chew the fodder well, their fattening may still be profitable, by reason of the low price at which they may be had: they also thrive very well. Many persons, even in England, are of opinion that cattle fatten better the more they have been previously worked: it is certain also that they are then obtained at a cheaper rate. According to these persons, when animals thus exhausted and reduced in condition by excessive labor are fed more abundantly, they acquire new flesh of more delicate fibre, and more succulent, even if already somewhat advanced in age: their fattening must, however, be carried to perfection.

A castrated bull should not be put up to fatten till he has lost all his bull flesh, either at the plow, or other labor. He must, therefore, be worked constantly for two years. His flesh will then be as good and succulent as that of an ox castrated while young.

Castrated cows are rarely seen in this country. When, however, such cows are made to work like oxen, they are particularly well-adapted for fattening, and furnish meat as delicate as that of any other kind of cattle. Where skillful operators are to be found, the castration of young cows is considered quite as safe as that of bull-calves. Instances are known of this operation having been performed with perfect success, even at the age of three years. Among the heifers brought to us from the principality of Oldenburg, we occasionally find some that are castrated.

Whoever would pursue the fattening of cattle continuously, will do well to dispose of them habitually to an honest and experienced cattle-dealer at such a price as to allow him a reasonable profit. For when the dealer becomes familiar with the manner in which cattle are fattened on a particular farm, and the meat produced upon it gets into favor with retailers or their customers, he will not fail to avail himself of the cattle of that establishment, and even though the cultivator may occasionally obtain a higher price by taking his own beasts to market, he will probably, in other cases, find himself embarrassed by so doing. As these dealers are well acquainted with the trade, and know at what time and under what circumstances cattle of a particular degree of fatness are most in request at certain places, the cultivator may often profit by following their directions in the arrangement of this system of fattening, the time of stalling his cattle, and the rapidity with which the most esteemed degree of fatness is to be produced.

An enormous amount of fat, artificially produced, and increasing the weight of the cattle to one-third more than the ordinary standard, can be advantageous in particular cases only: when, for instance, a high price is set on that which is uncommon. Every pound of flesh which a beast acquires beyond the usual weight costs perhaps a third more than when the animals are raised only to the degree of fatness common to their breed. The price obtained for it should therefore be proportionably high. This, however, cannot be depended on, unless a certain degree of luxury has been induced in the choice of provisions.

The necessary qualities and training of draught-oxen have been treated of in a previous portion of this work, and the cost of their maintenance.

It is not probable that the use of cows for cultivattng land may be established and generally diffused: such a practice would greatly increase their profit. See *Neue Annalen*, bd. iii., st. 1, s. 181, and the following.

SWINE.

In all rural establishments, both great and small, the keeping of pigs is almost indispensable, because the various kinds of refuse of the dairy, kitchen, and garden can scarcely be used in any other manner. This part of the management must, however, be carefully distinguished from the *breeding of swine* properly so called. It is impossible to pronounce, in general terms, on the advantages or disadvantages of this last-mentioned branch: the circumstances under which it will be profitable or not must be carefully considered in each particular case.

If all things be properly taken into account, it will be found that the rearing of swine is rarely advantageous in localities where they must be fed during winter on good grain, and there is not a sufficient supply of pasturage or green food for them in summer. Small profit also will be realized by breeding them in places to which they are brought in large numbers from less cultivated countries, and therefore at a lower price. Equally small will be the profit in the neighborhood of large towns, where not only the milk as it comes from the cows, but likewise the refuse of the dairy, the potatoes, and other fallow crops, can be readily and advantageously turned into money.

On the other hand, the rearing of swine is profitable where potatoes and turnips are grown in large quantities for feeding cattle, where there is a considerable quantity of bad and light grain among the corn, or where the pastures are damp and marshy and unfit for sheep. This branch of economy will also be found advantageous in rural establishments containing large dairies, the refuse of which cannot be more profitably employed, or extensive breweries and distilleries, particularly when there is no abundant supply of low-priced pigs from other countries, and consequently those which are reared may be easily disposed of, either fat or lean. Or again, where there is a good trade in salt meat, and facility of exporting bacon or hams.

There is, perhaps, no branch of economy the profits of which vary so much from year to year as the rearing of swine, particularly in certain countries. The price of pigs is often reduced by one-half, or doubled, in the course of two years, on account of the rapidity with which these animals increase and diminish in numbers. When a high price leads to increased production, and the value of grain subsequently rises, the markets become glutted with swine, because every one endeavors to get rid of his surplus stock. The owners begin to find out that the grain required for feeding their pigs will scarcely be repaid by the sale of them, and consequently they endeavor to get rid of the young ones. A year after, the number of pigs becomes considerably reduced in all the rural establishments in the country, and the market-price consequently rises. Every one then becomes anxious to keep pigs for his own domestic use, and each consumer endeavors to outbid his neighbor, so that frequently, by the next year, the price rises enormously high. I have seen pigs which, two years before, would scarcely fetch three rix-dollars, sold for ten or twelve, without having cost much to the breeder. This is one of the cases in which a cultivator may easily be alarmed by a rise or fall of price, and allow himself to be guided by general opinion without examining its foundation. He may thus be induced to take false steps, and diminish instead of increasing the number of his pigs, without considering that since the greater number of breeders are diminishing theirs, his own would, in two years' time, be likely to yield a large profit. When on the other hand, the generality of cultivators are tempted by a high price, which, contrary to all experience, they imagine must always continue, to increase the number of their pigs, the more prudent breeder will see in this very circumstance a motive for diminishing his stock, without, however, completely giving up this branch of economy.

The breeds of swine best known in the north of Germany, but nevertheless crossed in various ways, are the following:

(*a*). Moldavian, Wallachian, and Bothnian pigs; distinguished by great size, dark gray color, and very large ears.

(*b*). Polish, or, more properly speaking, Podolian pigs; also very large, but of a yellowish color, and having a broad brown stripe along the spine.

These two races furnish very large pigs for fattening, but they require a proportionably large quantity of food; besides, they are not very productive; the sows seldom have more than three, four, or five young ones at a birth.

(*c*). Bavarian pigs, usually marked with reddish-brown spots. They are much esteemed for the smallness of their bone, and the facility with which they fatten, but their flesh is considered too soft.

(*d*). Westphalian pigs, of considerable size and very productive; they bring forth ten or twelve at a time.

(*e*). The so-called English pigs. I do not know whether they really come from England, but the English certainly pay great attention to the management of swine, and possess many different breeds. These pigs have longer and deeper bodies than the Westphalia variety, but they require pasturage and food in general of a very substantial quality.

The crossing of these two last-mentioned races is considered advantageous.

(*f*). The common German pig. This breed differs in its characters in different provinces, and is of various colors, white, gray, black, and spotted. It does not attain the size of the preceding, but may be supported on a smaller quantity of nourishment, and is more easily fattened. This race might doubtless be improved within itself by the use of better nourishment, and the prevention of breeding till a later period. But those who undertake the management of pigs on a larger scale than usual, generally seek to obtain another breed, at least for the sake of crossing it with the native race.

(*g*). The black, fine-haired African pig has lately been brought to this country from Spain, together with a flock of merinos, by Baron Vincke, who has introduced them upon his estates at Friedland. This variety does not grow so large as those already mentioned, and is scarcely adapted for fattening, but grows rapidly and keeps up its condition even when poorly fed. It is therefore very valuable, both as a porker and for its hams. The crossing of this breed with one of larg-

er size has produced a medium variety, which, as far as observation has hitherto gone, appears to be excellent in every respect.

(*k*). The Chinese pig, much esteemed in England, and introduced some time ago, into this country. It is distinguished by a very hollow back, a belly reaching nearly to the ground, quietness of disposition, and by not turning up the ground much. It does not attain a very great size, but grows fast, and is much esteemed in England as a porker.

The male pig is called a *boar;* the female a *sow;* the young one, while it feeds on its mother's milk, a *sucking-pig*.

The Germans also make use of various words for denoting the age of pigs, but there are no corresponding terms in other languages.

In the breeding of swine, as much as in that of any other live stock, it is important to pay great attention, not only to the race, but also to the choice of individuals. The sow should produce a great number of young ones, and she must be well fed to enable her to support them. Some sows bring forth ten, twelve, or even fifteen pigs at a birth, but eight or nine is the usual number, and sows which produce fewer than this must be rejected. It is, however, probable that fecundity depends also on the boar; he should therefore be chosen from a race which multiplies quickly.

Good one-year bacon-hogs being much in request, we must do all we can to obtain a breed well adapted for producing them. Swine of such a breed may be known by their long bodies, low bellies, and short legs. Long, pendulous ears are usually coupled with these qualities, and attract purchasers. If, however, as is often advisable in large dairies and cheese-factories, hogs are to be sold at all seasons to the butchers, greater attention must be paid to quickness of growth and facility of gaining flesh, so that the animals may attain their full growth and be ready for killing before they are a year old. This quality is particularly prominent in the Chinese and African breeds, but among our ordinary varieties, hogs are often met with which are better adapted for this purpose than for producing large quantities of bacon and lard.

The boar should be selected from a race well suited to these several purposes; he must be sound and free from hereditary blemishes. He should be kept separate till he is about a year old, and has finished his growth, otherwise he will begin to leap very early. He is usually castrated before completing his third year, otherwise his flesh becomes uneatable. If, however, he is of a peculiarly excellent breed, which cannot be replaced, his flesh may be sacrificed for the sake of preserving him for breeding a few years longer.

A boar left on the pasture, and at liberty with the sows, might suffice for thirty or forty of them: but as he is usually shut up, and allowed to leap at stated times only, so that the young ones may be born nearly at the same time, it is usual to keep one boar for ten or twelve sows. Full-grown boars being often savage, and difficult to tame, and attacking men and animals, they must be deprived of their tusks.

The sow must be chosen from a race of proper size and shape, sound and free from blemishes and defects. She should have at least twelve teats; for it is observed that each pig selects a teat for himself and keeps to it, so that a pig not having one belonging to him would be starved. A good sow should produce a great number of pigs, all of equal vigor. She must be very careful of them, and not crush them by her weight; above all, she must not be addicted to eating the afterbirth, and what may often follow, her own young ones. If a a sow is tainted with these bad habits, or if she has difficult labors, or brings forth dead pigs, she must be castrated forthwith. It is therefore proper to bring up several young sows at once, so as to keep those only which are free from defects. Sows and boars must not be raised from defective animals.

Sows are almost always in heat till they have received the boar; they get into this state even at the age of four or five months; but they are commonly not put to the boar before the end of their first year. It is indeed, often deferred for two years, when it is desired to raise a large breed from one of middling size.

Sows are sometimes required to produce only one, sometimes two litters in a year. When highly fed, they may be covered three times in thirteen months; but this is rarely advisable. If two litters be wanted in the year, as is usually the case in establishments where this branch of economy is pursued on a large scale, and there is a sufficiency of nourishment for the purpose, the boar is put to the sow at the beginning of October and the end of March. As the sow goes with young from four months to eighteen weeks (some persons profess to have met with examples of sows going for twenty, or even twenty-one weeks, and to have remarked that old sows carry longer than young ones), she brings forth in March and August. But if she is to produce only one litter, she should litter in April, and the pigs be reared on pasturage. The arrangements to be made with relation to this matter will be determined by the various objects contemplated, and the general circumstances of the establishment. Sucking-pigs born in August or the beginning of March require good winter-feeding. When the only object in rearing swine is to turn the pasturage to account, and then sell the young pigs, it may be preferable to have but one litter, in April. Badly arranged, cold sties may also afford a reason for not having more than one litter produced in a year. But when the management of swine is well arranged, and winter-food abundant, it is always advantageous to have two litters in the year.

Well constructed buildings are perhaps of greater importance in the economy of swine than in that of any other kind of live stock. Success, indeed, is mainly dependent on attention to this point, all other care being useless without it. The pigs should be separated according to age, sex, and condition: a particular space, or sty, is therefore required for each of the following descriptions of animals:

(*a*). For pigs just weaned;

(*b*). For young pigs, which might otherwise be wounded or hunted by the large ones;

(*c*). For full-grown pigs, comprising the castrated of both sexes, sows which are being reared, and those which have farrowed and had their young ones weaned;

(*d*). Small sties for each sow suckling her young;

(*e*). Fattening-sties;

(*f*). Sties for the boars.

In the construction of these habitations, care must be taken that the animals are warmly housed, and the sties at the same time well aired, and clean; for though swine will roll in the mire to refresh themselves, a clean sty is nevertheless of primary importance to them; the piggery must also be provided with every convenience for winter-feeding; and if the food is to be chiefly derived from a dairy, brewery, or distillery, the piggery should communicate with this building. It should be exposed to the sun, and, if possible, surrounded with a yard, in which the pigs may be allowed to go out in separate divisions. Lastly, care must be taken to preserve the dung and urine, so that no manure may be lost.

For the rest, the construction of piggeries belongs to rural architecture.*

The sow during her pregnancy must be well fed, not to excess, but in the same manner as a fattening hog, for she will otherwise be liable to miscarry. Above all, she must not be allowed to suffer from hunger when her delivery is approaching, for such a circumstance might induce her to eat the after-birth and her young ones. It is well to be acquainted with the day when conception has taken place, because the time of delivery may then be calculated beforehand, and the necessary precautions taken. The sow must then be carefully watched: when she is likely to farrow in the night, the swine-herd, or the female servant who looks after the pigs, should sit up with her. It is always best to give a separate sty to each sow; or, at most, to leave together only two which are accustomed to one another; otherwise the young ones will be in danger of being crushed.

The sow must be supplied with good litter; but not in very great quantity, for the pigs might bury themselves in it, and be crushed to death, without any fault on the part of the mother.† The young ones, as they are born, must be taken away, and collected together, until the delivery is over, and the after-birth has come away; this precaution is necessary, to obviate the risk of their being crushed by the mother by creeping under her belly, while she is suffering the pains of labor.

A quarter of an hour after delivery, or even while the sow is ridding herself of the after-birth, the swine-herd endeavors, by gently scratching her belly and teats, to induce her to lie down, and then he puts the young ones near her. It has been observed that each sucking pig has its own peculiar teat, and does not willingly go to another; and likewise, that the fore teats almost always yield more milk than the hinder ones, for the pigs which suck at the former become larger than the rest. The smallest pigs are therefore put to the fore teats, so that they may attain as great a size as the rest.

When several sows farrow at once, and one of them has but a small number of pigs, she may be made to suckle some of the young ones belonging to those which have produced too many.—They must, however, be put to her before she gets up, that she may not be aware of it. The number of young ones often exceeds that of the teats; in such a case, if recourse cannot be had to the method just spoken of, the smallest pigs must be killed, that they may be eaten as sucking pigs by those who like that dish.

Sows, at their first farrowing, usually produce but few young ones; a sow which brings forth a great number the first time is highly valued. An old sow which brings forth fewer than eight pigs at a birth is not worth much. Those which have very low bellies, reaching almost to the ground, usually produce but few pigs in comparison with the number which might be expected from them.

As soon as the sow has farrowed, water containing ground barley is given to her: she must be well fed while suckling, that she may give plenty of milk. She may be fed upon sour milk and ground barley, bran, and oil-cakes well soaked in water: all extraordinary diet likely to bring on diarrhœa, either in the mother or the young ones, must be avoided. Good dry litter must be given to her, and often changed; the quantity, however, must not be very great, for fear of the young ones hiding themselves in it.

Young pigs are often castrated at the age of two and a half or three weeks; but they then grow up weaker, smaller, and higher on the legs, than those upon which the operation is not performed till they are six months old. It is, however, less dangerous when performed early: if it be deferred, the males and females must be separated, both in the sty and on the pasture, till they have been subjected to it.

Cruel mistakes are often committed in castrating: these must be carefully guarded against, especially in places where the castrators of pigs are licensed. Animals of both sexes are sometimes imperfectly castrated: the effect of this treatment is certainly to unfit them for breeding; but they nevertheless retain the desire of copulation, and not only become heated themselves, but derange the whole herd.

When pigs are to be castrated, they should for four and twenty hours previously be supplied with food in moderate quantity, and such as will not swell in the stomach. Great care must be taken in choosing the animals to be retained for breeding.

The pigs, after castration, must be left quiet, and fed on clear wash, made of linseed-cake and sour milk, till they get well.

It is not difficult to wean pigs, because they begin to eat as soon as they are a fortnight old.—Separate troughs, lower and shallower than the rest, are provided for the young pigs, unless they are intended to eat out of the same trough with the old ones.

Each sty should have a separate egress into the pig yard, so that the old and young pigs may easily be let out, and supplied with fresh water.

When the young ones have sucked for four weeks, the sow is let out without them, and they without the sow, alternately—the young pigs, however, only in fine weather; in this manner they get accustomed to dispense with one another's society. The mother is also scantily fed, that her milk may diminish, and she may repulse her young ones.

* A description of this branch of architecture will be found in Gilly—"Anweisung zur landwirthschaftlichen Baukunst Herausyeeben von Friederici," Bd. 1. Abth. 2, s. 12, u. f. A.

† For this reason, the straw put under the sow should be more or less cut. [*French Trans.*

Finally, the pigs are fed with a little barley, to accustom them to hard food, and sharpen their teeth, as it is said.

Weaned pigs are at first supplied with five meals per day; when they have attained the age of six weeks, this number is reduced to four; after nine weeks they are fed but three times per day, like other pigs.

They are easily accustomed to take their food cold; this is for the most part advantageous, as warm food might injure them. When they do not eat all the food in their trough, the remainder must be taken away and the trough well cleaned. A fresh supply must then be given to them, but in smaller quantity.

Sour milk is undoubtedly the best and most wholesome nourishment for young pigs. When there is no market for cheese, the most profitable mode of disposing of the skimmed milk is often to give it to these animals. A pig eighteen weeks old, fed on a sufficient quantity of sour milk, will be larger than one a year old fed in a different manner.

After having attained the age of nine weeks, the young pigs must be accustomed to the same food as the old ones, without, however, being left in the same sty with them. If they have not been castrated while sucking, the sexes must be separated till that operation has been performed. The weakest of the young pigs must, if possible, be kept apart, for the others bite and keep them from their food, and thus their growth is stopped.

In summer, swine are fed either on pasturage or in the sty.

In well cultivated countries it will rarely be advantageous to have grass land fed off by pigs; but in localities where there are hollows covered with sour grasses, marshy spots, cold, and covered with bushes, and a great many ponds—or where snails are numerous, and the ground contains a large number of worms and roots which are agreeable to those animals—there is no better mode of turning the pasturage to account. Success is, however, mainly dependent on the employment of a good swine-herd, who will take care to select a proper spot for the animals at each moment of the day, and for every change of temperature. At noon they must be sheltered from the sun, and taken home, if no shelter can be found in the fields. The first pasturage on the stubble cannot be consumed in any manner more advantageously than by pigs, because they avail themselves of the seed which has fallen on the ground. Moreover, they crop the plants which they find, and tear up roots not easily destroyed by the plow—the *sium falcaria*, for example, which cannot well be destroyed by any other means. They almost clear the soil of insects, worms and mice. Where root-crops are cultivated, they also find abundant nourishment on the field after the crop has been taken: there is no better way of disposing of the residue.

But when pasturage is scanty, they always require a little additional food at night and morning.

In establishments possessing large dairies, swine are house-fed during summer. This method affords a means of disposing of the sour milk, as well as of kitchen and garden refuse, tailing corn, and similar matters, which for this purpose are mixed, and allowed to turn slightly sour. But the best nourishment for house-fed pigs in summer consists of green lucerne given to them just as it is mown, or chopped and mixed with whey, or slightly sour milk. But pigs thus fed must have the range of a spacious yard, in which they can find clean water, or they must be taken to a place where water is at hand for them to drink and bathe in.

The feeding of pigs in winter may be found advantageous either in breweries, distilleries, and large dairies, or where root-crops are cultivated in large quantities. In large dairies the greatest deficiency of food usually occurs at the beginning of winter. The pigs may then be fed on sour milk mixed with water; and supplementary food may be found in kitchen refuse, bran, mill-dust, siftings, and the seeds of weeds which have been separated from the corn: these are given to the pigs either ground or soaked in warm water. If cows begin to calve at a time when scarcely any cheese is made, a portion of the milk may be disposed of in this manner. Moreover, when fallow crops are cultivated, there can be no deficiency of winter food, particularly when advantage is taken of the several kinds of refuse just mentioned.

Good grain is usually too dear to be given to pigs. These animals must, however, be well fed, or they will yield no return. By good feeding, a first year's pig may be raised to the value of one which is two years old; and we have only to consider, farther, whether it is advantageous to give in one year the quantity of food which would suffice for two.

In arranging his system for the breeding and fattening of pigs, the cultivator should determine beforehand what breed he can most easily dispose of in his own country, and what market he will be likely to find for each variety. The following kinds may be disposed of:

(*a*). Weaned pigs, in countries where there are a great many small cultivators and gardeners who keep a cow, and can send their pigs to grass.

(*b*). After harvest pigs, which have attained half their growth, or are less than a year old, may be sold to persons who fatten a pair of these animals for their own use, and prefer those of middling size, because they are cheaper.

(*c*). Full-grown pigs, either to brewers and brandy distillers in towns, or to establishments which have a large quantity of refuse, or can procure it in their own neighborhood; or generally to all those who do not concern themselves with the breeding of swine, but yet possess the means of fattening them.

(*d*). Half-fattened pigs, to pork-butchers at all seasons.

(*e*). Pigs completely fattened, to household establishments, both in town and country, at Christmas.

In farming establishments for the breeding and fattening of swine, great additional security is obtained by determining beforehand which of the five preceding classes, and how many of each class, are to be maintained and sold. These pigs must then be sold at the price which they will fetch. By keeping the young ones longer than is consistent with the system of the establishment because we are dissatisfied with the price offered to us, we shall most likely be embarrassed for want of food, and ultimately obliged to sell them at a still lower rate. Indeed, farmers, after keeping their pigs for a long time under these circumstances, have often been compelled to send them

to market. It is, doubtless, unpleasant, after having obtained the price of three rix-dollars for weaned pigs in one year, to be obliged to sell them for eight groschen in the next—a circumstance which I have known to occur several times; but we must, nevertheless, make up our minds to the loss, if the general plan of our establishment require it.

When sucking-pigs are not sold, matters are usually arranged so that the young ones born in spring may be kept either for breeding or for fattening in the following autumn, and those born in April to be sold for fattening when they are a year old.

Full-grown pigs are the best adapted for fattening. A pig of good breed, and well fed, may reach his full growth in a year. But, generally speaking, they do not arrive at this stage till two or even three years old. It is common in England, though not in this country, to feed pigs in summer on fodder-plants, such as clover, lucerne, tares, buckwheat, and spurry. For this purpose, the pigs are either turned into the fields, or fed in the sty or in permanent enclosures. The green-meat just spoken of is cut up like cabbages, and mixed with various kinds of refuse proper for feeding pigs: the whole is then placed in large walled reservoirs, salted, pressed, and left to turn sour. The pigs are fed on it in autumn, and get very fat.

In large dairies, milk may be used for feeding pigs, even if they are not bred on the farm.—These animals are fed either on sour milk or whey: many farmers are of opinion that the former may be used for this purpose more profitably than for making cheese. It is certain that pigs fed in this manner soon attain considerable weight, provided that, toward the end of the fattening, a little ground barley is put into the diluted milk to thicken it. The flesh of these pigs is excellent. But when the fattening has been begun in this manner, it must be continued: for all other kinds of food would diminish instead of increasing the weight of the animals. Ground corn can be used only as a supplementary aliment.

When large quantities of root-crops are raised, they may often be very profitably used for fattening swine. At the present day, potatoes are most commonly used for this purpose; they are usually steamed, mashed, and mixed with water. Pigs will readily eat raw potatoes for a short time, and in moderate quantity; but soon take a dislike to them when fattening. When the fattening is nearly finished, a little ground corn is added to the potatoes to complete it. Some persons think carrots better than potatoes for fattening; pigs willingly eat them raw, and thrive well upon them. The flesh of hogs thus fed is said to be particularly firm.

If pigs are to be fattened entirely on the refuse of the brewery, it must be given to them in very large quantities. They gain flesh rapidly at first, but do not become good bacon-hogs unless supplied with more substantial food toward the end of the fattening. This refuse is of better quality when small beer is not extracted from it. It must be kept under water to prevent it from heating.

The refuse of the brandy-distillery is more substantial, and better adapted for fattening, than that of the brew-house. According to *Neuenhahn*, eight Nordhausen scheffels (equal to about six of Berlin), used daily in the still, will supply food for fifty hogs: this author remarks, however, that it is better to keep below than above the full number—the loss occasioned by leaving a portion unconsumed not being nearly so great as that which arises from a deficiency in the supply.—At first this refuse must be mixed with water, as the hogs will otherwise refuse it; in fact, it makes them giddy and unable to keep their feet; afterward, the quantity of the food is gradually increased, till they are completely accustomed to it. Neuenhahn says that the refuse of the brandy-distillery cannot be given to the pigs too warm, or too soon after its removal from the still; and that it never makes them hot; but, on the contrary, when allowed to get cold and stale, it is rather injurious than beneficial to them. On the other hand, I have been assured by many experienced distillers who fatten large numbers of hogs, that it requires great attention, and the employment of a man on whose care we can rely, to prevent the refuse being given to the animals while too warm, for it then injures and retards them to a great extent. It must be given sometimes thick, sometimes thinned with water, in order to keep up the appetite of the animals.

The residue of the manufacture of starch, the products of the various washings which this preparation involves, and the refuse of wheat, are far superior to brewers' and distillers' refuse. Hogs fed upon these articles fatten more quickly, produce firmer flesh, more substantial bacon, and a greater quantity of lard. At first the animals eat these matters with great avidity, and often to excess; in that case, they refuse them after a time. The quantity must therefore be carefully regulated, and the troughs kept very clean. If this mode of feeding be used alternately with one of a different nature, the fattening will be effected with greater certainty. The quantity of this refuse collected at once is often greater than can be consumed at the time: it is difficult to preserve, because its animal portions soon putrefy. The only mode of preservation is to dry it, make it into cakes, and bake it.

Corn-feeding cannot be really advantageous, excepting in a limited number of cases. It is, however, frequently resorted to, and in various ways. According to observations of the English, a good hog increases in flesh from 9 to 10 lbs. for every bushel of grain, half barley, half peas, that he eats; or from 14 to 15 lbs. per Berlin scheffel; hence we may calculate how far corn-fattening can be profitable. Grain is given to pigs in the following ways:

(*a*). Crude and dry. The animals chew and bruise it very well; but they must be well supplied with water. Pigs have sometimes had their stomachs burst after eating to excess of this food; it must, therefore, be given with great caution.

(*b*). Grain soaked in water cannot well be injurious; but it has been often remarked that swine will not eat much of this food. If it can be dried again, after germinating, or made into malt, it will be improved. It may also be left to turn sour, and will then be more useful and agreeable to the animals.

(*c*). Grain burst, by boiling, is particularly useful for fattening: this method saves the expense which would otherwise be requisite for grinding the corn: it will not, however, effect any saving, unless fuel be cheaper.

(*d*). Ground corn is, however, the best and most trustworthy food. Swine are rarely cloyed with it when properly given to them. It should be soaked in water some time before, then mixed

with a larger quantity of water, and well mashed, so that none of it may remain in lumps, for that would probably bring on indigestion and other disorders. The corn should not be soaked in boiling, but in tepid or cold water. When pigs are fed on ground corn, it is usual to give them toward evening a little grain in its natural state; this is said to keep up their appetite.

Of grain, properly so called, barley is by most persons considered as the most advantageous for swine; others prefer oats; but pulse, such as peas, tares, and beans, are much more efficacious; only when pigs are to be fattened on them, they must not previously be fed ground barley alone, for they will then refuse the pulse. If the latter are to be afterward given alone, small quantities of them must from the beginning be mixed with the barley; but pigs not yet accustomed to barley willingly eat pulse, whether hard, soaked, boiled, or ground. According to experiments made in England, pulse, especially peas, fatten much more easily, and are more agreeable to swine, when slightly sour.

In general, fattening with sour dough is commonly extolled as cheaper and quicker than that produced by grain. Ground corn, or coarse meal, is mixed with warm water in a pail, and made into a paste; yeast is then added, and the whole kept at a somewhat high temperature: in twelve hours it becomes sour. A portion of this sour dough is then mixed with water, to form a thick mash for the pigs. When the dough is nearly finished, a fresh portion of meal or ground corn is added to the remainder. This mash, made of sour dough, is much relished by the pigs; it is likewise wholesome and refreshing to them. But, when given alone, it serves only to fill them up: it causes them to gain rapidly in flesh; but the meat is light and flabby, and the quantity of lard and bacon small. It is better, therefore, to add to it every day a quantity of unground grain, especially peas.

Some persons profess to have been wonderfully successful in fattening their pigs on bread.—The bread for this purpose is made of coarse barley or rye flour; it is cut into pieces, dried in the oven, then soaked in water, and given in the form of a thick mash. When soaked in sour milk or whey instead of water, it is said to surpass all other kinds of food in the quickness and efficacy with which it fattens.

I consider maize as superior to all other kinds of grain for fattening. It produces very solid flesh, and gives firmness to the bacon. Swine are very fond of it. With us it is seldom used excepting to complete the fattening, each pig being supplied night and morning with a handful or so of maize-seed: the quantity of fat is thereby greatly increased. Whole ears of maize may, however, be thrown to the pigs: they know very well how to extract the seed. This practice is very general in Hungary, where large numbers of Moldavian pigs are thus brought to the highest state of fatness, and afterward sold in Vienna.

In fattening pigs, the following rules must also be observed:

These animals are more inclined than any others to over-eat themselves, and then they are much retarded. Hence, it is always better, if one extreme must be incurred, to give them too little than too much. If they are attacked with indigestion, they must be kept without food for four and twenty hours, and then a few handfuls of unground corn, with a little salt, must be given to them six hours before resuming the ordinary food.

Swine eat a great deal when first put to fatten, but much less when fat. The most nutritious and substantial food is, therefore, commonly reserved for the end of the process. Many farmers, however, particularly in England, think that these animals should at first be supplied with very substantial food, in order to increase their vital energies; then with a larger quantity of some less nutritious kind of aliment; and, finally, with that in which the nutritive power is most concentrated.

It has generally been found useful to give pigs, from time to time, half an ounce of pounded antimony, either upon their solid food or in sour milk. This medicine not only maintains their appetite and facilitates digestion, but also preserves them from leprosy. It may be given every week or fortnight, especially when the pigs appear dull and lose their appetite.

The space in which pigs are shut up should be rather small; they will be more quiet and peaceable in consequence. If, however, there should be among them one that is weak, sickly, and ill-treated by the rest, he must be immediately removed from them, or they will kill him. When pigs are hungry, they are apt to bite one another; but, when well fed, they are quiet enough. It is best, however, to divide the troughs into separate portions, placing before each a board with notches in it just large enough for a pig to put his head through.

The strictest regularity should also be observed in the hours of feeding.

It is of great importance to keep pigs as clean as possible, and give them dry litter. Bathing twice a week accelerates their fattening and makes them more quiet.

It only remains to speak of fattening in the woods. Swine thus fed never attain the highest degree of fatness; acorns, however, make their flesh and bacon very firm; beech-mast, on the contrary, produces flabby muscle and unsound fat, which runs when heated.

Swine should be kept in the woods day and night, and be provided with proper covering or shelter. If brought home at night, or at liberty to return, they get heated and lose all that they have gained in the day. Fattening in the woods is doubtless the cheapest of all methods, but there is not always a sufficient quantity of food. If the pigs do not quickly arrive at a certain degree of fatness, they derive but small advantage from this mode of feeding, for want of rest and warmth.

When pigs are accustomed to pasturage, that of the woods is always preferred by them. It is indispensable, however, that they have a proper supply of water.

SHEEP.

The management of sheep has sometimes been too much decried, sometimes too much extolled, in comparison with that of other domestic animals. Leaving out of consideration those peculiarities of situation which must always affect the profit to be derived from one species or the other, it will be found that their profit has always been, in a great measure, *determined by circumstances*, and the *mercantile circumstances* resulting from them. Farther, it is undeniable that the partic-

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ular care and attention devoted to one kind of live stock or another, have also greatly contributed to the profit derived from it. It is generally acknowledged that cattle of any kind, when well fed and looked after, repay much more fully the judicious outlay incurred for their maintenance, than ill-kept animals repay the niggardly expenditure which the owner is obliged to bestow upon them. Profit is derived only from the excess above that which is absolutely necessary; the quantity of nourishment which just keeps an animal alive is, to a certain extent, lost. It is for this reason that the flocks of sheep, formerly so badly fed, yielded no profit; and that, in the opinion of most farmers, fodder and pasturage, notwithstanding their trifling value, were absolutely lost upon these animals, which consequently owed their preservation to nothing but the urgent demand for the manure obtained by folding them on the land. But when attention was aroused to the profit yielded by improved sheep, and greater care and better food were bestowed upon them, larger returns were soon obtained, while, at the same time, the breed was improved. The profit derived from sheep then became so great that they were soon more highly prized than horned-cattle and the dairy—which, in fact, were decried. Unfortunately, there were but few rural establishments capable of properly maintaining these two kinds of live stock at once; so that one was sure to suffer by the preference given to the other, and the breed declined more and more.

Commercial circumstances, which themselves depend on politics, have for some years favored the rearing of sheep, by raising considerably the price of wool. Hence, throughout almost all Europe, animals of this kind are more highly prized by farmers than horned-cattle; and, though this high estimation has been excited by the merino breed alone, it nevertheless exerts more or less influence on the ordinary races, and causes them to rise in price.

It is almost universally admitted that *ten sheep* cost as much as *one cow*, whether pastured or stall-fed. This proportion was originally based on the kinds of sheep and cows maintained in the north of Germany, both of which were in the most miserable state. The same proportion seems, however, to hold good when both races are improved together; for good sheep, as well as good cows, require twice as much food as bad ones, whether at pasturage or in the stall. Even if the quantity of food consumed by sheep does increase with the improvement of the breed at the same rate as with cows, the proportion is, nevertheless, kept up by accessory expenses and additional risk.

If, then, in localities where these two species of live stock can be equally well maintained, it be asked, "Which kind ought the farmer to increase or diminish, to the detriment of the one or the advantage of the other?" the question will usually be answered by the reply given to the following: "Which will yield the greater profit, ten sheep or one cow?" This question cannot be answered in general terms, but is easily resolved in each particular case, even by a very superficial calculation. Among other considerations, temporary occurrences have, at the present day, considerable influence on this matter; their indications must, undoubtedly, be attended to, though not to such an extent as to preclude the possibility of altering the proportions between our several kinds of live stock according to the manner which circumstances may render advisable.

The proportion which for the last ten years has subsisted between the price of meat and butter on the one hand, and that of wool on the other, though both have been very high, has decidedly given the advantage to *the sheep* over *the dairy*, when both sheep and horned-cattle have been fed upon pastures equally well adapted to either. But this is not the case when cows are stall-fed, for this mode of feeding saves so large an extent of ground, which must otherwise be used for pasturage, that the *equality in the net produce of the soil is reëstablished by it*. But though stall-feeding, which is much better adapted for horned-cattle than for sheep, should even strike the balance in favor of the former, it would still not follow that, under existing circumstances, the number of sheep should be diminished; on the contrary, it *ought rather to be increased*, because the stall-feeding of horned-cattle *saves a quantity of pasturage which cannot be turned to account in any other manner*.

An acquaintance with the various and beautiful breeds of sheep to be found in various parts of the world is an interesting subject of natural history, but does not belong to the science of Agriculture. I shall not, therefore, speak of the races met with in the distant parts of Europe. The several breeds peculiar to Great Britain are mentioned in my "English Agriculture." On this matter the reader may also consult Culley's "Observations on Live Stock, containing Hints for choosing and improving the best Breeds of the most useful kinds of Domestic Animals." London, 1786; 8vo.

I shall here content myself with speaking of those which are found in Germany, whether established there from the remotest times or lately introduced.

There are four principal varieties, viz.:—

(*a*). The sheep of the *landes* or heaths.
(*b*). The breed of the marches or low countries.
(*c*). The ordinary native breed.
(*d*). The merinoes.

The *sheep of the landes* are small; they are scarcely found anywhere excepting on the landes of Luneburg and Bremen. They would not be profitable in other countries; indeed, they would scarcely be able to live elsewhere, for they feed almost wholly on furze, and soon become excessively fat, and lose their health when put upon richer pasturage. All sheep of this breed have horns; they are seldom quite white, but gray, brown, or black. Their wool is generally coarse and harsh to the touch; some, however, have finer wool, and others, among their long, coarse wool, have also a short, fine sort, which, however, is difficult to separate. They are usually shorn twice in the year: first, toward St. John's day, when a ram will give from 2 lbs. to 3 lbs. of wool, a wether from 2 lbs. to 2½ lbs. and a ewe from 1 lb. to 1½ lb.; and secondly, about Michaelmas: at this time, however, they are not shorn so close to the body, and the quantity of wool obtained is scarcely a third of that cut off at the first shearing. This wool, especially the short kind, is used in the manufacture of common hats; coarse stuffs are also made of it, particularly a tissue of wool and other articles mixed together. Frequently also there is a large demand for it in foreign countries, for the manufacture of sailors' coats and cloth list.

Sheep of this breed yield a very small return; but in their native countries they cost scarcely anything, living almost wholly on furze both in winter and summer. They scratch away the snow to get at this plant, and when it is too deep to enable them to do this, the snow-plow is used to clear a passage for them to obtain their food. Dry furze is also given to them in the stall or under sheds, where it is usually spread out for them, together with a little horse-dung. If a little buckwheat-straw be given to them from time to time, it is only as a relish. Some farmers, however, give a little buckwheat-seed to the ewes at lambing time, and a little hay to the lambs. Notwithstanding the hardiness of this race of sheep, they cannot endure passing the night in open pens.

Their weight is very small; a tolerably good wether yields only about 30 lbs. of net flesh. Their flesh is rich, of delicate fibre, savory, and pleasant to the smell.

This race of sheep has been crossed with the ordinary native breed, and has produced an intermediate variety called half-bred: this mixed breed presents no advantage; it requires better feeding both in the stall and at pasturage; without this it will degenerate; and, nevertheless, it yields very little more than the pure breed of the landes.

The sheep of the marches, or low countries, otherwise called *the Friesland breed*, include several varieties, all of which seem, however, to spring from a common stock, and to have been merely changed by the care and food bestowed upon them, and the choice of individuals for breeding. Those of the most fertile districts are very large and fat; they may be raised to a weight of 120 lbs. net flesh, or even more. Their wool is thick, of various degrees of delicacy and softness, never frizzled, but smooth, and fit for combing. They yield on the average 10 lbs. of wool when fed on very rich pastures; the smallest, however, give but 6 lbs. or 7 lbs. This wool is very useful for the manufacture of certain kinds of stuff, especially stockings, whether knit or woven; but it is not good for cloth-making.

The ewes of this breed bring forth sometimes two, sometimes three, lambs at a birth; some have been known to produce even more. The variety of smaller size and bone fatten easily, they are fit for killing at the age of two years. They give plenty of milk, which is often drawn from them. I have known ewes of this breed, not even of the larger variety, to yield every day a quart of milk, which was pronounced by judges to be of excellent quality.

These sheep then might be expected to be very profitable; all things considered, however, they are not so, in reality; for in proportion to their produce they require very substantial pasturage and feeding. But few of them are therefore maintained, and those only in countries where they can be fed on pastures of which no other use can be made. In lowlands protected by dikes, these animals graze on the dikes and beyond them. When they are to be fattened they are allowed to go among the other cattle on fattening pastures, or placed in grass fields which are not fit for other animals, but are used as meadows, and require to be left at rest for a year, and improved by sheep-folding. The sheep eat off the old grass, though it may be mixed with rushes; the meadow is greatly improved by this treatment. The animals are seldom attacked with watery cachexia while on the pasture; if they are, they must immediately be sent to the slaughter-house.

Sheep of this breed may be everywhere maintained by good stall-feeding on clover: but from various trials which have come to my knowledge, this mode of feeding appears to be too costly in proportion to the return. The only variety of the race which seems to be profitable is a small kind, with very thin bones, fed on very rich and upland pastures. This variety has perhaps been produced by crossing. The others are met with in almost all low countries, and are thought by some persons to have sprung from the ordinary native breed, gradually improved by rich pasturage. To me this opinion appears totally unfounded. I rather think that they came originally from the banks of the Rhine and Elbe, and have thence been transplanted into the countries where they are at present found.

The *ordinary German sheep* exhibit several varieties, but nevertheless appear to have a common origin. The various degrees of attention bestowed on their breeding and maintenance, appear to be the sole cause of the observed differences, which, though now hereditary, would soon change if the animals were otherwise fed. In all parts of Germany where sheep have for some time been treated with care and fed on good pasturage, especially on the mountains, the breed is found to be superior, even in quality of wool, to that of places where they are scantily fed, and treated as mere occasional accessories.

In Lower Saxony there is a particular variety distinguished by the name of the Flemish or Rhine breed. But this variety has preserved its peculiar characteristics in those places only where it has received the very best food and most unremitting attention; where this has not been the case, I do not think that it differs perceptibly from our Pomeranean and Prussian breed. It would be worth while to examine the various gradations of fineness and quality of wool in the several provinces of Germany. For a long time, however, we have concerned ourselves least in the pursuit of the very inquiry most within our reach; and now that the merino breed is introduced among us, the ordinary German races are scarcely thought worthy of closer investigation. The introduction of a German breed of peculiar excellence, and the perfecting of it *within itself*, might, however, and probably would, repay the trouble bestowed upon it; and such a breed might, by the weight of its wool, by greater vigor of constitution and facility of fattening, counterbalance the higher value of the merinoes. The wool of the country varies infinitely in fineness, elasticity and thickness. There is a race of German sheep whose wool serves for the manufacture of cloth of average fineness and great durability. There are others, on the contrary, whose wool is so coarse, that it can only be used for stuffs of the most ordinary description. Our sheep likewise differ greatly both in the thickness and quantity of their wool: superior fineness and elasticity are almost always united with great thickness of fleece.

Our native sheep are certainly more capable than the Spanish breed of enduring bad pasture and stall-feeding; they are likewise more robust and exposed to fewer diseases. If, therefore, the general circumstances of a rural establishment are inconsistent with the maintenance of sheep

on pasturage and fodder of the quality required for enabling the merino breed to yield a sufficient quantity of wool, the farmers must not be visited with unqualified censure for keeping to the native breed. If, however, it be asked why the management is not such as to allow the maintenance of merinoes rather than of the native sheep, the question assumes another aspect, under which we do not propose to examine it in this place. I think, however, that in localities where economical arrangements cannot be altered, and pastures cannot be improved, many rural establishments will find no advantage in substituting merinoes for a good native breed, especially since the universal multiplication of the former will raise the price of good coarse wool in proportion to that of the finer sorts. I know that many assiduous farmers in several countries have for a long time been engaged in trials to improve the native breed by itself; but they have probably by this time fallen into the method of crossing with merinoes. For slaughtering, the native breeds, especially certain varieties,, are, undoubtedly, better than pure merinoes, which can never be brought to the same degree of size and fatness, or made to yield meat of so rich a quality.

The *merino breed*, which we may consider as naturalized in Germany, though not yet very numerous in its pure state, must, I think, be very well known to all who will read this work. In 1811 I published, by order of the Minister of the Interior, a "Manual of the Economy of fine-wooled Sheep" *(Handbuch für die feinwolligè schaafzucht)*, which may be found also in the "*Annalen der Fortschritte der Landwirthschaft*," Bd. i. s. 1. In this work I think I have said all that it is most important to say on the subject. If to this be added the works of Tessier, that of Ch. Putet, and the treatise by Poyféré de Cère, inserted in the "*Annalen des Ackerbaues*," Bd. s. 641, a complete course of instruction on the economy of this improved breed of sheep will be obtained. To avoid copying my own observations and those of other authors, I shall here say but little on the subject.*

That excellent writer, Ch. Putet, has shown in the clearest manner the necessity of having pure breeds, free from foreign blood on the mother's as well as the father's side, and to take the rams from them not only when we wish to introduce the pure breed, but likewise when our object is to perfect that which we already possess. Not only does improvement proceed faster by means of such rams, but, moreover, the breed cannot be preserved from degenerating without the use of rams of unmixed race. Hitherto it has not been positively ascertained, whether, or how long, a ram of improved breed, but descended by his mother's side from sheep of this country, will retain his superior qualities, so far as to obviate the fear of degeneracy when fresh crossing is not resorted to.

Some Englishmen, particularly Dr. Parry, think that by crossing their own Ryeland and South-Down breeds, they have obtained a race, not only equal to the true merinoes in fineness of wool, but superior to them in shape of body, and firmness and quality of flesh: they are likewise so confident of the permanence of this race, that they endeavor to perfect it within itself without having recourse to new merino rams. They say that, just as their noblest breed of horses, though originally obtained by crossing with Arab stallions, is at the present day possessed of qualities which render it much more valuable than the Arab race itself, so it will also be with their sheep. The facts which they adduce do indeed powerfully support this opinion; but it must not be forgotten that the Ryeland breed was before possessed of considerable fineness, and that the price of their wool in England was only one-third lower than that of the finest Spanish wool: so that, in fact, this Ryeland breed was for a long time considered as of common origin with the merinoes; and some persons were even of opinion that the merinoes were descended from individuals belonging to it, which had been taken over to Spain. But even though the English have attained their object in so short a time, we are not warranted in anticipating the same result with our native breed.

In Spain, the merinoes are not all alike; they are divided into two principal classes, the Leon and Soria breeds. The several flocks of the former of these also differ from one another in qualities; and though each may possess certain advantages over the rest, it must nevertheless yield to them in others. These finer varieties are also observed among the flocks of pure merinoes in Germany, and owe their quality either to their origin in Spain, or to choice of individuals, particularly of the rams. The fineness and other qualities of the wool may be equal in these several varieties: but sensible differences are observed among them in the quantity which they yield upon an equal amount of food, and in their size, strength, and fitness for particular kinds of pasturage. Up to the present time, however, nothing positive has been established respecting this matter: for there has been too much design in the observations made upon it. As, however, in the selection of rams, every one endeavors to obtain the particular qualities which he has in view, these varieties will probably in time become more permanent and better characterized.

The varieties will probably become much more strongly marked in this country than even in Spain: for with us the classing of the male and female is much better arranged than it can be in the latter country, where it generally takes place promiscuously. The English have shown how much the form and qualities of animals, particularly of sheep, are influenced by the selection of individuals for breeding. "Bakewell," says Lord Somerville, "seemed to have the power of modeling a sheep just as he liked, and then giving it life."

It is thus that some of our principal breeders of sheep work upon size of body, considering that a greater extent of surface will, under given circumstances, yield a larger quantity of wool. Others prefer smaller animals whose wool being of closer texture equals in quantity that of the larger sheep; such sheep, even though inferior in quantity of wool, may, nevertheless, be satisfied with a smaller quantity of food, and thus a larger number of them may be maintained for the same cost.

* Several merino sheep have this winter been killed on my estate at Genthad, on the borders of the Lake of Geneva, and their flesh has been pronounced by all who have eaten it, equal to that of the best sheep that our butchers import from France. The kind of food seems to have an essential influence on the quality of the meat. I have known Swiss wethers, of breeds whose flesh had but very little taste in their native country, to yield excellent meat after feeding for a year or two on our pastures. On the other hand, I am of opinion that the proportion of the quantity of meat and fat to the weight of the animal when alive, is essentially owing to the nature of the breed; and in this respect I consider the merinoes as inferior to the German breeds mentioned by our author, and likewise to the Swiss. 1815. [French Trans.

Some cultivators prefer short, others long, legs; and these points are really not so immaterial as some persons think. Short-legged sheep are more quiet while grazing; they are preferable for pastures situated at a small distance and close together. Long legs, on the other hand, enable the animals to walk more easily either to the pasture, or thence to the fold or sheep-house. There is a variety distinguished by a triple collar of wool round the neck, and usually by a large dewlap hanging in front of the chest: some persons set great value on this dewlap; others do not like it, because the wool which grows on it is of third-rate quality only. In some sheep, the wool grows down to the hoofs of the hind feet, and even to those of the fore feet; in others, only to the knees.

Some persons regard this as an excellent quality, inasmuch as it indicates a disposition to produce abundance of wool; others, on the contrary, do not approve of it, because the wool which grows on these parts is of bad quality. But all breeders are agreed that these qualities are hereditary. It remains to be determined, by more accurate observations, the relation which they bear to the quantity and quality of the wool. Hitherto we have not, in this country, been able to appreciate the form and constitution of the body in the merino breed, or their disposition to produce meat and fat, since it has not been much the practice to castrate male lambs, but only ewes no longer fit for breeding. Quality and quantity of wool are undoubtedly the principal points to be attended to; it remains only to ascertain how far these qualities are consistent with the characters just mentioned. It is easy to agree in considering such and such a shape as excellent, without assigning to it any particular utility; but this is an affair of fashion, and therefore ephemeral.

The merino breed is distinguished from others by slower development, shedding its teeth later, not so soon coming to maturity, and being longer in attaining its full growth: its progress may, however, be accelerated by more nourishing food. On the other hand, sheep of this race live to a greater age, and become stronger than others. Merino ewes have been known to retain all their teeth till their fifteenth year, and produce healthy lambs at that age. This is certainly a rare occurrence; but these ewes may easily be kept till ten years old. Merinoes are also distinguished by a peculiar laziness of disposition; even the lambs are less frisky than those of other breeds.—These sheep are said also to be more stupid than others, because the ewes will suffer their milk to be drained by strange lambs, whereas those of our country will not readily allow any but their own lambs to milk them. This is by no means an unimportant matter; for the stronger and livelier lambs are apt to rob the weaker ones of their food. It is therefore very important in this breed that the lambs be all brought forth nearly at the same time, and possessed of equal strength.

For the rest I must, as already observed, refer to my *Manual of the Economy of fine-wooled Sheep*, lately published.

Some persons are of opinion, that ewes may be covered without injury at the age of two years, or even a year and a half: others maintain that it should be deferred a year longer, especially for merinoes, whose development is comparatively slow. The majority are of the former opinion; and it is certain that well fed ewes may, at the age of two years, produce fine lambs without injury to their health. In Spain, this is the usual mode of proceeding. If any breeder in this country should wish to multiply a good breed quickly, or proceed rapidly with the improvement of his own, he would certainly do well to follow this method. On the other hand, it is undeniable that ewes which do not bear till their third year, grow larger and acquire stronger constitutions; it is probable, also, that they live longer. Whoever, therefore, would obtain a large and vigorous race, should keep his ewes from the rams till they are three years old.

Rams are usually not allowed to leap till three years of age.

In the management of sheep, it is very desirable to have all the lambs born at the same season, and within an interval of four weeks, with merinoes this is absolutely necessary. The number of rams in a flock must not, therefore be too much restricted: the best proportion is that of one ram to twenty ewes.

The time of putting the ram to the ewes is determined by that at which we wish the lambs to be brought forth: sheep generally bear for twenty-one weeks and a few days.

Ewes generally get into heat for the first time in the sixth month after lambing. Certain late observers, especially Putet, recommend that this first inclination be taken advantage of; first, because impregnation may then be most safely relied upon; and secondly, because the healthiest lambs are obtained from the connection which takes place on this first indication of rutting. Others maintain the opposite opinion, considering it better to defer it till the second time that the ewe comes into heat; that is to say, till three weeks later, in order to give her time to recover her strength after suckling.

The former method would accelerate the lambing season by a month in every year; moreover the rams would be too much excited in the hot season.

It is doubtless advantageous to have all the lambs born early, especially when we have in view the rapid multiplication of a a breed, and intend the young ewes to be covered at the end of their second summer. But for this purpose, an abundant supply of good fodder must be laid up for the winter, in order to keep the ewes rich in milk till they can obtain pasturage, and to supply the lambs with the food best adapted for them. The fear of not having sufficient fodder is, perhaps, the principal reason why some cultivators like their ewes to lamb in March; for experience has quite removed the fear that lambs will be hurt by the cold of winter. Many experienced breeders have advanced the lambing-season to the month of December.

The rams are kept apart from the ewes, and among the lambs, till the season arrives. When the time is at hand, the rams are more substantially fed, before they are let in among the flock of ewes. Unless it be desired to make a selection in the individuals, I do not think it necessary to remove the rams during the day, and admit them only at night. If, however, we wish certain ewes to be covered by particular rams, we must adopt the method described at p. 47 and the following, of my *Manual of the Economy of Improved Breeds of Sheep, (Handbuch fur Vendelle Schaafzucht)*. When the time, which lasts about four weeks, is over, it is best to remove the rams.

At the beginning of her pregnancy, the ewe is satisfied with somewhat scanty fodder and pas-

turage: but as she advances in that state, she must be better fed. The more nearly ewes approach their lambing-time, the more gently must they be treated: they must on no account be hunted by dogs; and care must be observed in taking them into and out of the fold, that they are not squeezed in passing through the doorway.

Ewes require the greatest attention at the time of delivery. The signs which announce this event are, swelling of the generative organs, swelling of the udder, and formation of milk. They generally lamb without difficulty; but sometimes the labor is rather protracted. We must not, however, seek to anticipate Nature by giving premature assistance: this can only be required when the lamb, or some one of its members, is badly placed in the womb, an accident which rarely happens when the ewes have been properly tended. But if assistance must be given, the person who renders it should be well acquainted both with the actual and the required position of the lamb, as well as with the manner in which he ought to proceed to rectify it; all assistance given without this knowledge is likely to do more harm than good.

The chief source of trouble, in many instances, is to induce the ewe to take to her lamb after delivery. This difficulty, however, only arises when the ewes have been badly fed; if they have been abundantly supplied with food, the superabundance of their milk induces them to push the lamb to their teats. In the contrary case, the ewe and lamb must be lodged in separate pens, and the lamb allowed to suck, from time to time, while the mother is held by her feet.

The success of the lambs cannot be better ensured than by supplying the ewe, while suckling, with good and abundant food. It is said, however, that untoward results have sometimes arisen from over-feeding; this, however, has, in all probability, happened when the animals have previously been badly fed.

After three or four weeks the lambs may receive some additional nourishment, such as a mash of meal or oil-cake, and a little soft hay; the place where they feed is to be parted off with hurdles, wide enough to allow the ingress of the lambs, but not of their mothers; or the lambs may be fed when the ewes are away. The lambs should suck for eighteen or twenty weeks. Those which are weaned earlier, for the sake of their mothers' milk, remain poor and sickly for the rest of their lives. Lambs should be weaned by degrees; for this purpose they are supplied daily with a larger and larger quantity of good fodder, or rich pasturage, and kept more and more from their dams. As soon as a lamb is completely weaned, it must be kept as far as possible from its mother. that they may not disturb one another by their bleating. A month will probably elapse before they forget one another completely, and the lambs lose the recollection of the teat; lambs have even been known to begin sucking again after a month's separation.

Male lambs are usually castrated at the end of three or four weeks; the younger they are, the more easily is the operation performed. When the females are six weeks old, their tails are cut at four or five inches from the root, to prevent them from soiling themselves.

The age of the sheep is known by their teeth; the same organs are likewise used to designate them.

Besides the molar-teeth, sheep have eight incisors in the lower jaw, but none in the upper; this number they usually bring with them into the world: these first teeth are more rounded and pointed than those by which they are afterward replaced.

At the age of a year, or a year and a half, the two middle teeth are shed and replaced by two new ones of larger size. The animal is then called a two-toothed sheep, or yearling. The latter name is also given to it when a year old.

After the age of two or two and a half years, the two teeth next to those just mentioned are dropped, and larger ones come in their place. The animal is then called a four-toothed sheep.

At three or three and a half years, the third pair of teeth drop out, and are also replaced by larger ones, so that there remain but two of the original teeth, one on each side. The sheep is then said to be six-toothed.

In the following year the two last teeth are also shed, and the animal is then said to have a perfect mouth. The formation is then complete.

In the sixth year the teeth begin to wear away, the two in the middle becoming blunter and shorter. The teeth appear, however, to be longer, because the gums retract; but, when examined closely, they are easily seen to be worn at the top. As soon as the teeth are completely worn away, and begin to decay and fall out in pieces, the useful age of the animal is past, and it must be got rid of. If we would preserve it longer in the hope of obtaining more lambs from it, we must feed it upon particularly tender fodder; by this treatment sheep may be sometimes brought to a very advanced age. The teeth then no longer continue close together, but have vacant spaces between them: the upper lip increases in size, and falls over the lower.

This mode of designating sheep by their teeth must be well borne in mind when we are talking to a shepherd: we must not, for example, confound a sheep of four teeth with one of four years.

A sheep less than a year old is called a lamb. A male of this age, which has not been castrated, is called a ram lamb; one which has undergone that operation a gelded lamb.

After the first or second year they are called yearling rams and yearling wethers.

Those which are set aside, not to be used for breeding, are called refuse sheep.

The feeding of sheep must be so arranged as to afford them, as far as possible, equally substantial nourishment throughout the year.

The ewes must, however, be somewhat better fed during the last stage of their pregnancy, and likewise while they are suckling lambs which are not fed in any other way. Nothing is more injurious to pregnant or suckling ewes than to be overfed at one time and half-starved at another.—In the latter case, all food of a highly nutritive character brings on disease. The observation of this fact has led to the recommendation of avoiding particular kinds of fodder and pasture-plants of very substantial quality; in reality, however, these plants are not injurious, excepting when the sheep are led by hunger to eat them with too great avidity. Good nourishment bestowed upon suckling ewes is almost always repaid by the produce of the flock; more, however, in the case of fine than of coarse-wooled sheep.

The proportion between the winter and summer feeding of sheep varies according to warmth of the pastures and the temperature of the year. In our climate it is usual to allow seven-twelfths for summer, and five-twelfths for winter: matters are, therefore, so disposed as to provide a sufficiency of fodder for 150 days. If the least use can be made of winter pasturage, especially on the autumn sowings, this quantity will usually be found sufficient. But as the spring temperature is very uncertain in this country, and we might find ourselves troubled to provide nourishment for the ewes and lambs, it is proper to reckon upon at least 160 days. Any surplus that may remain will not be lost: if the prolongation of pasturage in autumn, or its anticipation in spring, allow of any saving of fodder, the quantity thus saved will form a commencement of provision for the following year.

Pastures for sheep may be divided into natural and cultivated, or artificial pastures.

By natural pastures we mean those which have been formed by natural causes, and not intentionally disposed for the feeding of sheep: by artificial pastures, on the contrary, those which have been purposely formed and arranged for sheep to graze on.

The former class includes—

(*a*). Natural open pastures usually found in dry, elevated and mountainous situations.
(*b*). Pasturage in the woods.
(*c*). Pasturage on fallow and stubble lands.
(*d*). Pasturage on meadows, in spring before the first crop springs up, and also in autumn.
(*e*). Pasturage on the sowings.

(*a*). Natural open pastures are gradually diminishing in extent, in consequence of the progress of cultivation; only the driest and poorest parts are devoted to sheep, the richer portions being reserved for horned-cattle, which cannot find nourishment on the former. Sheep are never pastured on the richer spots, excepting at the end of winter and in autumn. When the sheep can be removed early enough in the spring to allow a month to elapse before the horned-cattle are admitted, the pasture is not injured, but rather improved, because the sheep lower the grasses which shoot up before the rest. Their dung fully makes up for what they take from the soil, and the smell of it, which is so disgusting to horned-cattle, is dissipated before the grass springs up. Even a low, damp pasture does not injure sheep in their first year, provided it be free from stagnant water, and they are not left upon it for too long a time.

Dry and upland pastures, particularly on mountains, which, on account of their steepness and the thinness of the layer of earth upon the rocks, are not fit either for plowing or the feeding of horned-cattle, are commonly devoted exclusively to sheep. They are, moreover, particularly beneficial to these animals, whose nourishment upon them often affords the most profitable means of turning the land to account. On these elevated grounds, however, we sometimes meet with marshy spots, beds of springs, ponds, or waters running on the flats between hills and mountains; such spots are very dangerous to sheep. Places on which marsh-plants grow should be carefully avoided, even when deprived of their moisture by the greatest heat of summer. Particular danger is to be apprehended from localities where a layer of dried mud conceals a marshy substratum from which there arise mephitic gases affecting animals of all kinds with various diseases, men with fever, and sheep almost instantaneously either with a disposition to the watery cachexia or rot, very difficult to cure, or with other maladies more quickly fatal. It is not in the rainy season that this danger is most to be feared, for sheep then find sufficient nourishment on dry soils, and avoid places of this description. But when the herbage on dry soils is withered, the animals are driven by hunger to damp spots; and shepherds, apprehensive lest their sheep should suffer too much from hunger, are too much inclined to allow them to go there. Merinoës are decidedly more subject to this disease than our ordinary German sheep; it is, therefore, an indispensable condition in the maintenance of a flock of high-bred sheep to have all the damp places on these pastures drained by digging trenches and drainage-furrows, or at least to keep the waters within their proper bounds, and not allow them to cover the neighboring lands with mud.

(*b*). *Pasturage in the woods* varies greatly in quality according to the nature of the soil, and the kind and thickness of the trees composing the wood. A *thin wood* is almost equal to an *open pasture*; but the more thickly it is planted, the worse does the pasturage become. When the soil is fertile, and the grass not choked, but only shaded by the trees, the pasturage is sometimes abundant; but its nutritive power is but weak, and thence it does little good to the sheep. Moreover, there are often marshy spots in woods. With the exception of primroses nothing but *hard, dry herbage* will grow under *pine trees*: sheep find, therefore, but scanty food where these trees grow. Such pasturage is, however, considered wholesome and capable of correcting the bad effect of damp places. Pasturage in *thick woods* is, however, very injurious to the wool, and, therefore, the owners of fine-wooled sheep do not allow their flocks to go into them.

(*c*). In ordinary rural establishments the principal food of sheep is derived from *pasturage on the fallow-field:* the profit of sheep is, therefore, much diminished by all arrangements which prohibit fallowing. Hence almost all shepherds and amateurs of sheep are opposed to a system of cropping, from which fallowing is excluded, and particularly to the introduction of this system on the land of the peasant. It is for this reason that in almost all countries where the management of sheep forms a leading branch of rural economy, there exists an established usage, and even an obligation, of not plowing up the stubbles till the latest moment—an arrangement by which the real object of fallowing is completely frustrated.

Pasturage on the fallow-field is distinguished into that which takes place before the stubble is plowed up, and that obtained between the first and second plowing on the weeds and grasses which then spring up. The former is undoubtedly the more abundant of the two: the latter is agreeable to sheep, but lasts for a short time only; the thin shoots are soon devoured by the animals. Some persons think that this description of pasturage is likely to be injurious, especially in wet weather; but I do not think that any such danger need be apprehended, provided only that we do not turn half-starved sheep on a fallow-field richly covered with grass, for then, especially in wet weather, they would probably eat to excess.

Sheep generally find plenty of food as long as the stubble is not plowed up; but after this operation, the season of scarcity for these animals comes on. At this time most of the pastures are dry, because the greater number of grasses stop growing toward the middle of summer. The sheep must then depend on pasturage in the woods, the best places in which are therefore reserved for this part of the season. The ewes, however, gain but little strength on these pastures; it is, therefore, desirable to remove their lambs, reserving good pasturage in some spot or other for the latter.

After harvest comes *pasturage on the stubbles*, which is more or less nutritious according to the quantity of grass upon the field, and the number of ears which have fallen on the ground during harvest.

(*d*). *Pasturage on meadows*, sweet and well drained, is the most beneficial nourishment that can be given in spring to suckling ewes. The meadows used for this purpose are chiefly those which are irrigated with spring-water, because they soon become green, and the grass begins to grow by the end of March: the sheep are turned upon them as soon as they are sufficiently dry. Pasturage on such meadows, continued till the middle of April in a warm season, and the beginning of May in a cold one, is beneficial both to the sheep and the meadows, though some persons think that both are injured by it.* But marshy, sour meadows may undoubtedly be hurtful to sheep even in spring. In autumn, it is rarely beneficial, and often dangerous, to turn sheep on the meadows: but such pasturage is then very useful for horned-cattle.

(*e*). *Pasturage on the autumn sowings* is never injurious to sheep, provided that it takes place in dry weather: in winter during a dry frost, and in spring on very rich sowings and a fertile soil. But on a well-managed sheep farm, such pasturage should hardly be reckoned upon, because it may fail. Moreover, it should always be but moderately used, in order that the sheep may not be too much accustomed to it, for they will then refuse dry fodder, and suffer from hunger when they cannot get pasturage of this description. In many sheep establishments which are but ill supplied with fodder, this circumstance is not regarded as inconvenient; on the contrary, it is thought advantageous to let the animals eat their fill for a few days, and save fodder afterward. But this periodical scarcity is very injurious to the wool, especially that of merinoes, and still more to the lambs. Sudden change of diet may also injure the health of the sheep. They should, therefore, be well fed in the morning (but not upon straw alone, as some persons feed them), and allowed to eat but moderately of the pasture as a relish. This pasturage must be no less sparingly used in spring, when very thick sowing can be afforded, such as will not be injured by this mode of cropping, and appear adequate to form the chief support of the sheep till the other pastures are available. In this respect it is particularly necessary to exercise careful superintendence over the shepherd, and give him precise instructions; for these people are much inclined to use such pasturage to excess.

In rural establishments, in which various descriptions of pasture must be used in succession, according to time and circumstances, it is of the utmost importance to be well acquainted with them, and to lay down a plan of the manner in which they are to be used for the sheep, according to seasons and the weather, unless, indeed, we are content to be absolutely guided by the shepherd. Under such circumstances, shepherds make great boast of their local knowledge, knowing that others, not possessing this knowledge, may easily do a great deal of harm; and if, by chance, they find out that the master appreciates their merits, then every thing must be conducted according to their fancies. Whenever, therefore, a proprietor wishes to make any change in the management of his sheep, or any other part of his rural economy, and at the same time render himself independent of the shepherd, it is absolutely necessary for him to examine carefully all his herbage and pastures, especially those of which he has the use on his neighbors' grounds by virtue of some right or privilege, and, moreover, to make this examination at all seasons and in all weathers, in order to know the state of moisture of the land, and the unhealthy spots to be found on it. At the same time, he may make himself acquainted with the strength of vegetation of these pastures, the kinds of grass that grow on them, and lastly, with their situation and distance from the homestead, sheep-fold and watering-place. All this should be noted on the spot, and inscribed in the estate-book, with a reference to the plan.

The rights and privileges which the proprietor enjoys on other persons' lands, together with their extent and duration, must also be particularly noted.

A plan may then be drawn up for regulating the use of the pastures in such a manner as to give the greatest security for the maintenance of the sheep, and to admit of alteration according to circumstances, in case of its complete adoption being hindered by very bad weather, but always so as to obviate the necessity of submitting entirely to the will of the shepherd.

The best pasturage must be reserved for the lambs, the second-best for the suckling ewes, and the worst given to the barren sheep.

Under such circumstances, pastures of varied nature and considerable ext nt, present undeniable advantages, for they allow the animals to go from low situations, where the grass is rich, to dry, poor hights, and even into pine woods, to correct the bad effect of the rich herbage. Shepherds who insist on the necessity of great extent of pasturage are right, even though the pastures should be faulty in some respects.

Artificial or cultivated pastures are formed in the places assigned to them in the system of alternate culture. It is only on these pastures that sheep can be grown with certain and complete success. When those kinds of grass and clover best adapted for pasturage are sown on these fields, all less useful plants plowed up, and the soil properly drained, sheep find on them, at all seasons and in all weathers, a wholesome nutriment, which they eat quietly, without going far

* In our climate I have continually seen the first crop of sweet meadows greatly diminished when sheep have grazed upon them from the time of the latest frosts, that is to say, the beginning of April. Many examples likewise make me apprehensive lest, in this country, pasturage on watered meadows of this description, if long continued, even in dry weather, and after the meadows have been well drained, may yet involve some danger of the rot. [*French Trans.*

to seek it. The fertility of these pastures and their culture have been previously considered.

According to the extent of pasture required for a cow, the number of sheep which can be fed on a given extent of land may be determined, *ten sheep* being reckoned for one cow. This proportion may be safely relied upon if the sheep have also the use of pasturage on the stubble and fallow fields. As, however, the produce of the pastures is not the same every year, great certainty will be attained by reckoning upon a larger extent of ground, and reserving for cases of necessity a certain portion, which may be mown if not required for grazing. I have known *an acre of pasturage* to suffice *seven sheep during the whole summer*.

Sheep may be stall-fed in summer: this has been proved by unexceptionable trials. Such a mode of feeding is, however, attended with difficulties which most people would consider insuperable; difficulties, indeed, to which one would scarcely be warranted in exposing one's self without having, from year to year, a supply of hay and straw enough for six months at the least.

There is another mode of making the sheep consume a crop of clover, tares, &c. on the ground: it consists in placing hurdles before them just high enough to allow them to crop the herbage to a certain distance by stretching their heads over. The hurdles are moved forward as the sheep go on grazing.

The winter food of sheep consists of hay and straw. The straw contains very little nutriment and is, moreover, less substantial in proportion to its greater freedom from weeds, its ripeness and the care with which it has been threshed. The value of this pure straw is greatly exaggerated when it is said to be equal to half that of hay; this can never be the case excepting when the straw contains a large quantity of grain. It, however, fills the stomach and dulls the sensation of hunger when nothing of a more nutritious character can be given; indeed, there are many sheep-folds in which, from autumn to the somewhat advanced period of lambing, the animals are obliged to content themselves with pure straw, and such winter-pasturage as chance may afford them; but they come out from the winter season in a miserable state, yield but a very small quantity of wool, and that of coarse quality—fine-wooled sheep could not stand such diet. The *straw of leguminous vegetables* and *buckwheat* is more nourishing, especially when the crops have been taken while part of their leaves remained green. This straw may, therefore, be used as a help in establishments which are short of fodder: in such concerns it is frequently given to sheep as a relish, and reserved for the lambing season; whereas, in rich establishments, it is used only at the beginning of winter in place of hay.

Sheep are, however, mostly fed upon hay in winter; and, when a choice can be had, this hay is of the most nutritious quality, kept as green as possible, harvested in dry weather, and well preserved from mouldiness and all unpleasant smells. The hay of cultivated fodder-plants is also better for sheep than that of most natural meadows.

There is a great diversity in the quantity of hay given to sheep. In bad sheep-folds, 30 or 40 quintals are considered sufficient for the winter food of 100 sheep. But, in establishments where sheep of superior breed are kept, 75 quintals is regarded as the minimum of winter provision for this number of animals—making, for the 150 days during which the sheep are almost wholly stall-fed, 55 lbs. per day for 100 sheep, or rather more than ½ lb. for each.*

But experience shows that when the wool has acquired a great degree of fineness, and rises in price, it is profitable to give the sheep a more abundant supply of food, even if hay should be worth 12 groschen per quintal. A remarkable comparative essay on this subject is described in the second volume of the "Neue Annalen der Landwirthschaft," s. 123, in which fifty-one sheep, fed on a quantity of hay greater by 17¾ quintals than that given to fifty-one other sheep, yielded 75 lbs. of fine wool more than the latter;† but this hay, at the rate of 12 groschen per quintal, would amount to only 8 rix-dollars, 21 groschen. It is worth while to try, by exact experiments, up to what point it may be found profitable to increase the food of sheep, and whether there is a maximum beyond which this amelioration of food ceases to be profitable. If the latter supposition be correct, any surplus food will, of course, be more advantageously divided among a larger number of animals. Some great amateurs of sheep regulate the quantity of food to be given to them only by their appetites—which, however, in animals that are always properly satisfied with food, is not so great as in those which are poorly fed. Others think that greater advantage is gained by keeping a larger number of sheep; this, however, may easily degenerate into a system of starvation. In determining this matter, regard should be had not only to the quantity of wool, but also to the size and quick growth of the lambs, and the increase of flesh and fat in those which are not intended for breeding.

Two quintals of hay per head is usually regarded as the most advantageous quantity for fine-wooled sheep of ordinary size, which are not supplied with any other food; some farmers, however, consider this quantity too large, and think that it may be more profitably divided among a larger number of animals: they even look upon 1¼ quintals per head as verging on extravagance. But it should be remembered that, by giving more hay, we save straw; and therefore, when the latter is scarce, it may be economical to increase the quantity of the former.

It is also agreed that a sheep *requires 3 lbs. of dry fodder per day*: if its food be reduced below this quantity, it suffers from hunger, which is always injurious. But a ewe will eat 3½ lbs. of dried hay, with good appetite. The larger the proportion of nutritious hay to straw in this allowance, the more will the animals thrive.

In valuations, the feeding of sheep is sometimes put down at a price much lower than that which it really costs: but this is not easily discovered till more exact information has been obtained; for, at all events, when the shepherd receives part of the produce of the sheep-fold, only the amount of the valuation is put down: whatever is to be added to it is reckoned apart, and the

* A Berlin quintal contains 110 lbs. [French Trans.

† I have here omitted the calculation of the produce of wool, in which I think there is a misprint in the original. It was estimated at 70 rix-dollars, 10 groschen. [French Trans.

shepherd pays his portion of it: no shepherd who understands his business will object to this apparent sacrifice.

Where a sufficiency of hay cannot be obtained, *grain-feeding* is usually adopted, to make up the full quantity of food. Oats are usually preferred; but rye and barley, in proper proportions, are no less advantageous to sheep. In places where large quantities of peas, tares, beans or buckwheat are cultivated, they constitute the most usual kind of grain-food for these animals. Mashes of oil-cake are of great service, especially for lambs and suckling ewes: the refuse of the brandy distillery is also useful; but it must be given with caution, and before it turns sour. Many farmers have found that, when acid, it produces a bad effect upon the milk.

Corn is sometimes given to sheep in bundles, either unthreshed or only half-threshed; but the quantity cannot then be accurately measured. The grain is, however, more commonly given in the naked state, but mixed with chaff and slightly moistened. Sometimes, also, it is a little swelled by soaking in water; this method is particularly adopted with the seed of pulse. Other persons prefer giving it in the ground state, mixed with cut straw, or in a mash. Provender consisting of chaff and refuse corn is sometimes given to sheep.

If the price of grain be somewhat high, this mode of feeding will be among the most expensive that can be adopted: it is, therefore, resorted to only at lambing time, or in cases of necessity, or, as some persons recommend, for curing sheep attacked with the rot.

Instead of depending on grain, it is undoubtedly better *to cultivate root-crops of various kinds*, and use them to supply the place of a portion of the hay on which sheep are to be fed; perhaps even half. Numerous experiments have shown that all the ordinary root-crops are particularly beneficial to sheep, and preferable to all kinds of dry fodder, especially during suckling time.—Sheep are never injured in health by these roots, but digest them easily, as is proved by the readiness with which they eat them, *especially potatoes*, when once accustomed to them. When these vegetables are used in place of hay, their quantity must be proportioned to their nutritive powers, as already explained. It has been abundantly proved, indeed, that they may be used altogether instead of hay; but, if so, the sheep must be plentifully supplied with straw; and, after all, they thrive better when fed on roots and hay alternately. Sheep fed daily on 1½ lb. of hay and 1 lb. of potatoes, or 1 lb. of hay and 2 lbs. of potatoes, together with a good supply of straw, have been found to thrive particularly well, and give plenty of wool and milk.

Good pea, tare, or lentil-straw may, however, be used instead of hay when the sheep are fed on roots.

Acorns and *horse-chestnuts* afford nourishing food to sheep; they are particularly recommended for those which are attacked with the rot or watery cachexia. They are given in the quantity of about *a pound per day*, either in their natural state, or after being soaked for some days in water, and then dried in the oven: this treatment causes the husk to separate, and removes the rough taste.

In some countries, sheep are fed in a great measure on the leaves of the elm, lime, poplar, maple, ash and alder trees, the relative utility of which varies in the order here mentioned. The branches are cut in July, tied up in bundles, dried, and collected in heaps; they are then housed in a barn, to be given to the sheep as a supplementary food, particularly at lambing time. In places where this kind of food is regularly used, the trees which furnish it are arranged in three divisions, from one of which the leaves are gathered every year. When the sheep have eaten the leaves, the wood is used for burning.

Salt is undoubtedly useful to sheep at times, but should be regarded rather as a medicine than an article of food. The desire of licking salt is manifested by sheep precisely at the time when they require it. The opportunity of doing so is afforded to them without spreading salt upon their food, by suspending a lump of rock-salt in the fold, or making cakes of dissolved salt and meal, baking them, and either hanging them up in the same manner or putting them in the mangers. Brine is also made of a solution of salt and an infusion of aromatic herbs, viz. wormwood, buckbean, gentian, holy thistle, camomile, marjoram, rue, balm-mint, thyme, and feverfew. This liquid is placed in a wooden porringer; a pound of it will suffice a sheep for a year.

These animals require drink as much as solid food, and should have the opportunity of drinking often. It is only when, according to old fashioned custom, they have been allowed to suffer from thirst, that they are likely to injure themselves by drinking to excess; such injury would be most likely to result from their drinking stagnant or marshy water. When fed on succulent vegetables they are less inclined to drink than when they live on dry fodder. In winter, they are much disposed to eat snow; it agrees with them very well.

Dark, confined, damp stalls, such as have been too long used for sheep for fear of their suffering from cold, are highly injurious to their health. Sheep are naturally protected from cold, and they enjoy fresh air and light more than any other domestic animals. It is only when weakened by long confinement in a warm, damp atmosphere, which throws them into a state of perspiration, that they are injured by sudden exposure to cold. All intelligent persons are now convinced that light, airy, spacious sheep-folds are absolutely necessary, and that nothing need be apprehended from their coolness. Well-fed sheep may safely be exposed to a temperature considerably below the freezing point.

The experiment of keeping sheep out in the open air at night, according to the English custom, has been tried both in France and Germany. M. de Trembicki, of Lomna, near Warsaw, particularly deserves the thanks of the public for his attention to this matter ("Annalen des Ackerbaues," 1805. I. 721). An experiment of the same kind is recorded in the "Annalen des Ackerbaues," bd. xi. s. 452. But notwithstanding the possibility of keeping sheep out at night, a well-aired fold is much more advantageous to them; this has been shown in the ninth volume of the "Annalen," s. 83, by his Highness the Duke of Holstein Becq. Such a covering forms a useful protection to the newly-dropped lambs, especially in the very cold season: it likewise keeps off rain and snow, and prevents succulent fodder from being spoiled by frost. In rainy weather a smaller quantity of litter, also, serves for sheep in the fold, and their dung retains its moisture better.

The principal requisites of a good sheep-fold are sufficiency of room, currents of air so directed as to afford perfect ventilation without exactly coming in contact with the sheep, and a space or yard in front in which they can enjoy the open air as often and as long as they like. Some persons have built magnificent sheep-folds, with wide and numerous windows. There is certainly no objection to such folds; but sheep may be just as well kept in ordinary folds, built according to the old plan, provided the necessary ventilation be supplied, the doors be left open, and the sheep have liberty of going in and out at their pleasure. In large sheep-folds it is very convenient to have separate stalls or compartments for the several descriptions of animals. The fullest directions, in an agricultural point of view, respecting the construction of sheep-folds, will be found in Gilly's "Anweisung zur landwirthschaftlichen Bau Kunst von Friedrici."

Sheep Mangers and Racks.

Among the various modes of constructing mangers, the following is, in my opinion, the most suitable: A board, about sixteen inches wide, is supported on four tressels, and bordered with a lath about two inches deep. This board serves to retain the hay dust, and to feed the sheep with short fodder and roots. Double racks, joined together, and placed upon it. These racks are about 12 inches asunder at the bottom, and 10 at the top, so that they incline toward each other, and not outward, according to the old construction. This arrangement not only obviates the inconvenience of anything falling into the wool of the sheep when they pull the fodder out of the rack, but also prevents them from leaning over one another to eat, and thereby soiling each other's fleece. By this arrangement, also, the animals are prevented from jumping into the mangers, as they are very much inclined to do. The double rack is suspended by cords passing over a pulley attached to the rafters, or else to two cross-bars, by means of which it is raised above the board when the sheep are to be fed on short fodder.

I have elsewhere spoken of the advantages and inconveniences of night-penning as a means of improving land. That this treatment may not injure the health of the sheep, it must be adopted in the warmest part of the year only and in dry weather; moreover, the sheep must not be too crowded in the pens, but each must have a space of ten square feet. It is advisable not to expose them to a thunder-storm, but to take them back to the fold when such a shower is perceived to be coming on: but a sudden heavy rain does not hurt them nearly so much as a long continuance of cold, damp weather. Sheep must never be penned on damp ground: the drier and more sandy the soil, the less is it likely to injure them.

A flock of sheep includes the following divisions:

1. Breeding ewes.
2. Wethers, with which also the rams are usually kept.
3. Year-olds.
4. Lambs—these are kept separate during the summer only, because at the beginning of winter the lambs of the previous winter are taken into the division of the yearlings.
5. Fatted sheep, where fattening is attended to, and there are pastures fit for that purpose.

1. The ewes of the first division are distinguished according to age, and entered upon the register accordingly. The distinctions are as follows:

(*a*). Old or superannuated ewes.
(*b*). Full-mouthed ewes which have got their eight large incisors.
(*c*). Six-toothed ewes.
(*d*). Four-toothed ewes.

For the winter the animals are put in the division to which they properly belong in the ensuing spring only. Thus, the lambs born after the winter of 1809 are regarded as year-olds of the following autumn, and placed in the corresponding division for 1809-10. In the winter of 1810 they are classed (such at least is the custom) among those fit to receive the ram; that is to say, among the four-tooth ewes, though in reality they have yet but two teeth. A similar method is pursued with the other classes. Moreover, in a sheep-fold where improvement of breed is attended to, the ewes are distinguished according to their generations, which are distinguished by peculiar marks; viz., those of pure breed, and those of the fifth, fourth, third, second, and first generations. They are distinguished as follows:

OLD OR SUPERANNUATED SHEEP.

Pure	10
Of the fifth generation	8

FULL-MOUTHED SHEEP, WITH EIGHT TEETH.

Pure	20	Of the third generation	60
Of the fifth generation	40	" second "	40
" fourth "	60	" first "	20

The six and and four-toothed sheep are similarly distinguished.

Sheep are usually marked and counted three times a year:

1. At the beginning of winter, when those which are to be drafted are separated from the rest.
2. In spring, when winter-feeding is nearly over: the sheep to be drafted after shearing are then marked.
3. At shearing-time.

The register is consequently revised, or the number of sheep in each class and division noted, three times a year. Some persons perform this revision every month, but this is unnecessary, provided that care be taken to note once a month all changes which happen in the fold, and every increase or diminution of numbers.

The state of a flock during winter is considered permanent. In summer, the number is increased by that of the lambs, but it is also diminished by losses and removals which have taken place during the spring. If the flock consist of 1,000 sheep during winter, pasturage must be provided for at least 1,300.

Wethers, or sheep for fattening, are regarded in this country but as an accessory though necessary branch of sheep-husbandry. It is true that we sometimes meet with fattening flocks, consisting entirely of wethers and drafted sheep, bought for the purpose from owners of flocks, and fattened either for summer or winter; but sheep-husbandry is rarely undertaken with fattening for its principal object, as it is in England. The principal object with us is the wool: breeding and fattening are resorted to only from necessity. The multiplication of sheep for the former of these purposes is so rapid that our markets are glutted with drafted sheep; but the flesh of these animals being of indifferent quality, the taste for it has been lost; and the low price of bad mutton causes a depression also in that of good, at least in the Government duties hitherto in use. Hence it can rarely be profitable in this country to rear sheep especially adapted for fattening, and devote to that object the care which we bestow upon the wool, or pursue it, as the English do, to the detriment of the latter.

There is great diversity in the disposition to fatten and the goodness of the flesh in the several races of sheep. In England there are breeds of which ewes produce one or even two lambs in their second year, suckle them, and become fat either by autumn or during the following winter without being covered a second time. Such sheep are considered the most profitable of all; for the price of their meat well repays the cost of both winter-feeding and pasturage; the wool is regarded as only of secondary importance. This property does not, however, belong to all the English races: there are some which cannot be profitably fattened till the third or fourth year. There is also great diversity in the quality of the meat. Good mutton should not be spongy or very porous, but soft, of delicate fibre, and succulent. A moderate quantity of fat, mixed with muscular fibre, is much esteemed; but the excess of that substance, which shows itself on the outside sometimes in layers five or six inches thick, is fit only for the poorer class of people, who use this fat to eat with the leguminous vegetables on which they live.

Many Englishmen consider goodness of flesh and disposition to fatten incompatible with fineness of wool. This opinion is not, however, universal: some persons in England think that goodness of flesh and wool may be united. They have, however, seen abundant proof that the merino breed is very defective in these respects, and upon a given quantity of food produce flesh inferior, both in weight and quality, to that of any other breed. It is commonly considered that the greater value of the wool does not compensate for these disadvantages, at least in the system of English husbandry. Many farmers, therefore, without directly opposing the introduction of the merino breed into England, think that an intermediate race, possessing both qualities, might be formed by crossing, and a proper selection of individuals.

With us, in Germany, the production of meat is but a secondary consideration: generally speaking, we have no breed particularly famous in this respect. We must, however, remember, that upon a given quantity of food the pure merino race does not gain so much flesh, or produce meat of so good a quality, as the larger variety of our native breed. The wethers of the former race evidently make less progress than those of the latter; and when a butcher is permitted to make a selection among a flock of mixed sheep, he will reject all the merinoes, unless they have already gained a large quantity of wool, a circumstance which he very well knows how to appreciate.

Considering the great advantage which the merinóes present by the quantity of wool which they yield, we shall scarcely be prevented by the circumstance just mentioned from introducing the breed into our establishments, unless, indeed, a change of circumstances should greatly increase the price of mutton as compared with that of wool.

If, however, peculiar circumstances of husbandry should induce cultivators to direct their attention to the fattening of sheep, and to turn the milk of their ewes to account, it would be no less advantageous to have a good native breed, perfected within itself. When our only object is to keep wethers for fattening, and buy them for this purpose of breeders, we shall undoubtedly find the native breed the most advantageous, especially when we intend to fatten quickly, and therefore reckon but little on the wool which the sheep may gain during fattening.

It may also be found advantageous to keep sheep for fattening in localities where the pastures are rich but not very healthy, such indeed as to cause some danger of the rot or watery cachexia or on a moist, rich soil, where the stubble-lands and meadows yield abundant second crops, and at the same time lean sheep can be purchased at low prices, and sold at a good profit when fattened. When large quantities of root crops are cultivated, it may be found advantageous to fatten sheep during winter and sell them in May, for at that season there will seldom be any difficulty in finding a market for fatted sheep, particularly in the neighborhood of large rich towns, in which, at this time, good mutton is highly prized.

When the fattening of sheep is undertaken, it is best to bring it to perfection as soon as possible, and frequently to renew the flock. Wethers kept for a whole year will rarely pay for their food, whether they are stall-fed or pastured. If, therefore, we possess fattening pastures, they must be liberally used, that is to say, we must not put too many sheep upon them. A portion of the pastures must be reserved in order that the sheep may be placed upon them when the grass begins to get low on those which they have previously occupied: drafted ewes may then be put upon the latter to consume the rest of the grass. If this pasturage be not sufficient, additional food must be given in the fold, so that the fattening may be complete in eight or at most in ten weeks. If the fattening take place in winter, the sheep must from the first be supplied with as much food as they will eat; it is astonishing to observe the quantity that one of these animals will consume when in the middle of fattening. But fodder thus given will pay its expenses much better than that which is parsimoniously applied, so as not even in four months to bring the sheep to the degree of fatness which they might attain in two. Twelve wethers, of the native breed, which I once put upon trial in my sheep-fold, intending them for use in my own house, were fed with a scheffel of pota-

toes and a quarter quintal of hay per day: in six or eight weeks they became so fat and produced meat of so good a quality, that all who ate of it at my table declared that they had never eaten meat more succulent or of more agreeable flavor; they found out, in short, how it is that the English set so high a value on good mutton.

Wethers which are to be fattened at home should, while they are lambs and year-olds, be kept in such a manner that they may attain, during the time, to their full size and strength. The better sort of our native sheep may, by good feeding, be raised to an extraordinary degree of size and weight. This is proved by the wethers sometimes kept alone in stables from their first year to the time when they are put up to fatten; they may then be more sparingly fed. When sheep are bought exclusively for fattening, success depends chiefly on the selection and price of the animals purchased. In general, it will be found advantageous to buy the largest sheep that we can feed, even if we pay a higher price for them.

On large sheep-farms it is necessary to have a master-shepherd to overlook the whole; he usually receives a part of the produce, and is considered responsible for the success of the whole concern. He has under him shepherds to look after the suckling ewes, a shepherd for the wethers, one for the year-olds, and another for the lambs—the last is usually a boy.

The shepherd's occupation is in some respects a kind of trade, but it is often hereditary. The children of shepherds acquire from their youth a certain affection for sheep, and a peculiar tact in overlooking them; they become early and practically accustomed to the shepherd's life, often, indeed, so far as to unfit them for all other occupations. A good shepherd of this kind is certainly preferable to one who takes up the occupation at a later period of his life, and has to acquire the tact of watching sheep. The only thing to be regretted is, that certain prejudices and superstitions become inherited from father to son, and can scarcely be eradicated by the most palpable demonstration. Frequently there reigns among them a certain *esprit de corps* which induces them to combine for the purpose of deceiving and injuring their masters. A man possessing the qualities of an intelligent master-shepherd, but free from these prejudices and this party spirit, is a most valuable acquisition, especially where the cultivator cannot exercise a minute inspection over his sheep-fold, and direct his shepherds in the minute details of their duty.

In some countries the master-shepherds are so corrupted that it becomes necessary to select young persons of good character, and either train them up one's-self to the employment, or apprentice them in a well-conducted establishment in some other country. It is much to be wished that the schools of shepherds, so long wanted, and so often proposed, were actually established and organized. As shepherds have, from the earliest times, possessed the confidence of the people for treating the diseases of animals and even of men, and as they make use of various superstitious remedies, and even perform operations, this confidence might be turned to account by furnishing the pupils with some instruction in the veterinary art. They might then to a certain extent follow the occupation of a veterinary surgeon, which can never, except in certain countries, furnish full employment for any one.

At the present day, the inconvenience of allowing the head-shepherd, as well as the other servants, to keep sheep in the flock on their own account, is generally admitted. When such a practice was permitted, it was perfectly natural that the sheep belonging to the shepherd should be always the best, his lambs the finest, and that all the animals that died were not his, but the master's: all control, in short, was impossible. The custom was, however, not easily abolished, because all qualified shepherds insisted on its preservation, and it was consequently difficult to obtain one on any other terms. It was finally prohibited by law in the Prussian and several other States any proprietor, who should establish or perpetuate the practice being made liable to heavy penalties. The shepherds were therefore obliged to submit, and accept other conditions.

It was then determined what proportion they should receive of the total produce of the flock, a portion which they were consequently obliged to purchase without having sheep especially belonging to them. They were also obliged to bear their part of the accessory expenses, and a certain quantity of hay was appointed to be supplied to the flock without payment. Everything beyond this, such as salt, grain, &c., as well as all incidental expenses, were to be borne in common, so that the shepherd paid his proportion of them. This arrangement binds the interest of the proprietor to that of the shepherd; it amalgamates these two interests as it were, and prevents fraud, or at least throws obstacles in its way. It however occasions some difficulties in the appointment or dismissal of the shepherd, particularly when the establishment is considerable, and has for its objects the increase and improvement of the breed; for in either case a valuation will be necessary, and the shepherd who leaves has a right to claim his part in the increased value of the flock, since he has contributed to the expenses by which this increase has been produced.

Some persons allow the shepherd a certain portion of the produce, without obliging him to purchase part of the stock, sometimes even without requiring him to pay his portion of the incidental expenses.

If the proprietor be willing to exercise a very careful superintendence over his sheep-fold, and in some measure to take upon himself the office of director, or if he employ a clever assistant, he may engage men at fixed wages, and feed them or allow them a certain quantity of provision for their maintenance. In order to interest them in the success of the sheep-husbandry, it is a good plan to allow them a specified gratuity for every lamb that they rear in health to the beginning of winter.

It is of great importance that the shepherd train his dog well, and have him perfectly under command; for a dog which disturbs a flock at improper times may completely derange it.

The washing of wool on the sheep's back is always very imperfect, and is, therefore, adopted only to take off the grosser part of the dirt, which in well-tended flocks of fine-wooled sheep ought not to be tolerated. Wool is more or less cleansed by this washing. This circumstance raises or lowers the value of the wool in the eyes of experienced connoisseurs; but more complete washing diminishes the weight, and the loss which thence results is often more than an equivalent to the increased value of the wool. The chief inconvenience of washing on the back is the injury which

it does to the animal's health in bad weather; a circumstance which it is not always possible to avoid, if the time for taking wool to market should not admit of delay in shearing. Frequently when perspiration cannot be completely reëstablished before shearing, its suspension throws back the natural and even the internal grease of the wool. But the use of this washing is so completely established in Germany. and so generally recognized in the trade, that it would be difficult for a private individual to dispense with it. Our wool is not purchased unless it has undergone this washing, and we have not the necessary establishments for cleansing it thoroughly; moreover, if we even attempt this complete washing, purchasers will not usually pay the price which it is really worth, according to its actual weight, because they prefer to perform this last washing themselves when they sort their wool. An opportunity should be taken at a time when wool is much in request, for the proprietors of the best flocks to unite for the purpose of selling their wool either in the unwashed state or when thoroughly washed after shearing, and of establishing in every country where sheep are abundant the arrangements required for complete washing; these arrangements are now well known. It has been found that wool, when thoroughly washed after shearing, loses in weight about 54 per cent., provided it has not been previously washed on the back. In the latter process, the wool probably loses about 25 per cent. of its weight in the unwashed state.*

The success of washing on the back depends partly on the method adopted, which is variable—partly on the care bestowed upon the operation. and partly upon the water. Hard water has but little effect on the grease and dirt contained in the wool. Soft water, on the contrary, especially if it be soapy, renders the wool much whiter and cleaner; this is also the case with the water of the well at Möglin, of which I have had occasion to speak in the *Annalen des Ackerbaues*, bd. x. s. 390.

To diminish the ill effects of washing on the back with regard to the checking of perspiration, it is of great importance for the health of the animal, as well as the quality of the wool, to endeavor to restore perspiration before shearing, by keeping the animals warmer and feeding them better than usual; if possible, also, an interval of a week should elapse between washing and shearing, particular care being taken to prevent the sheep from getting dirty again.

Opinions are much divided respecting the comparative advantages of shearing twice or only once a year. With merinoes, and sheep of improved breeds, the practice of shearing twice a year has been generally abandoned; lately, however, some persons, who are in the habit of feeding sheep very plentifully and on very substantial food, have resumed it,be cause the wool of their sheep grows so fast and becomes so thick, that the animals are less inconvenienced by the double shearing than by the length of their wool. With well fed native sheep an increase in the quantity of wool has been obtained by two shearings, estimated by some persons at one-tenth. and by others at one-twelfth of the whole. In some countries it is thought that the wool obtained by two shearings is inferior to that of one year's growth; in others, on the contrary, this is denied: the difference of opinion arises, no doubt, from the various kinds of manufacture in which the wool is used. Hatters prefer short wool. Sheep accustomed to be shorn twice a year often lose their wool in the spring following the autumn in which the shearing has for the first time been omitted; it must then be pulled off by hand. This inconvenience is much more perceptible when the sheep graze in woods or among bushes. Shearing too early or too late always produces a bad effect on the animal's health; the only remedy for the mischief is a supply of very succulent food.

To obtain the proper quantity of wool, it is proper that the sheep be shorn close to the skin, and as carefully as possible, so that no wool may be left on the body in stripes. Skillful and practiced shearers must be employed, and well looked after; this the shepherd will aways do if he is to have part of the produce of the wool. The form of the shears and the equality of their blades is also of considerable importance.†

The shearer is usually paid so much per head. four or six pfennings.‡ A moderate addition to this sum will be well expended, if we can ensure by it that the sheep will be completely shorn. Shearing executed by statute-laborers is, as may be conceived, rarely performed with care.

When a flock contains sheep of various degrees of fineness, they must be separated. The rams, wethers, ewes, and year-olds are also separately shorn, and the wool of each class is kept separate.

In this country it is not usual to pick the wool, and put by itself that which belongs to each part of the body. A few fleeces are commonly placed one upon the other, so as to form a heap weighing about twenty pounds; they are then folded into bundles, the short, clean wool being placed in the middle. Each bundle is tied with thin pack-thread; or else the wool is put, without tying, into sacks.

In flocks of high-bred sheep an exact account is taken of the weight of wool of each animal, in order to determine its value accordingly. and make a proper selection of individuals for breeding; for richness of wool is probably an hereditary quality. This opinion is in reality supported by experience, so far at least as weight depends on thickness (that is, on the number of fibres). The length of the wool, by which its weight is no less essentially influenced, depends on the food and health of the animal.

Merino wool is heavier in proportion to its bulk than that of our native sheep. But if a sheep of our country give less weight of wool than a merino, the deficiency will doubtless be found to arise from its having been less substantially fed. Upon equal food, our best native sheep seem always to yield a larger quantity of wool.

For the particular care required for merinoes, and the mode of estimating the value of these animals, and of their wool, I must refer my readers to the works already cited.

* The amount of this loss varies according to race, country, kind of food. and the degree of cleanliness in which the sheep are kept. Merino wool sometimes loses five-eighths or three-quarters of its weight by complete washing. when the animals are well fed and the wool is very greasy. [*French Trans.*

† Excellent *shears* are now made at the manufactory of Schickler, in front of the Eberswold at Neustadt, A.

‡ About three farthings or a penny.

HORSES.

All that relates to the breeding, training, and management of horses, has been fully treated by many learned and intelligent men who have devoted themselves to this branch of knowledge. We are, however, still in want of a fundamental and scientific development of this branch of rural economy—a treatise which shall furnish a clear and exact summary of it, and distinguish that which is conformable to Nature from that which is founded on prejudice; for in this branch of husbandry we meet with prejudices no less deeply rooted than those which beset us in others. I have not the presumption to attempt such a summary; and this is certainly not the place for a treatise of sufficient extent to include all that is necessary, I shall therefore content myself with noticing what the farmer, in his individual capacity, requires to know of the breeding and feeding of horses.*

I cannot, therefore, undertake to give a description of the breeds of different countries, or of those which have been formed from them by selection of individuals, or by crossing.

The farmer's horse should be thickset, short, with broad chest and rump, round, muscular, and nervous; but not, as some persons think, large-boned. He should be not fiery, but rather lively; and above all he must be persevering and hardy, so that even when subjected to extraordinary fatigue, or badly attended to and poorly fed for a time, he may be able to put up with these inconveniences without being weakened or losing his health. A good foot is an indispensable qualification. The horse's strength must be proportioned to the loads which he has to draw, or the kind of soil on which he works. Strength, however, does not always depend upon size: there are many small horses which, when harnessed with others of larger stature, will beat them, and compel them to give way; but, as it is said, a large horse fills his harness better, and when free from blemish, is usually stronger, and takes longer steps. Large horses, however, require more food; and, on this account, those which are smaller, not from poor feeding, but by nature, are preferable, provided they are not to be ordinarily employed in very heavy work.

There is greater difficulty in finding a breed of horses perfectly well adapted to Agriculture than one of higher character; because attention has everywhere been directed to the latter, to the exclusion of the former. A good hardy race of plow-horses has been too often mixed with one altogether unfit for the purpose, even by those who are most zealous in the breeding of horses. In the national studs which many sovereigns have established, to the great advantage of their subjects, the object usually aimed at has been the production of good riding-horses; and in most cases the choice of stallions has been made with too little regard to the nature of the breed already existing in each district, the mode in which the animals were treated, and the nature of the pastures.

The very sturdy race of horses once common in Mecklenberg is no longer found, excepting on particular estates and rural establishments of that country, and perhaps, also, in Pomerania. In the former country it is sometimes found in a state of higher breeding, without, however, having lost those qualities which render it fit for agricultural purposes. The Holstein horses, often called Mecklenberg, rarely possess the qualities which the former looks for; but there is a race of Danish horses, known by the name of Wasserdenen, which is perhaps stronger and hardier than any other. Lithuanian horses are strong and robust, in proportion to their size; but, for the most part, too small. I am not in a position to form a judgment on the ordinary race of agricultural horses to be found in other parts of Germany.

In the fore part of this work I have considered the question, how far the breeding and training of horses can be an advantageous occupation for the farmer. When once a race well adapted to Agriculture has been obtained with a stallion who goes quietly with the mares that he serves, and covers the working-mares at the proper time, I am persuaded, from the considerations adduced in the same paragraph, that the rearing of foals on pasturage proper for the purpose, or even in the stable, will be found profitable—if, at least, the advantages of a uniform and well-known breed be taken into account. It is this system of breeding, and not the formation of a stud, that we here consider. The mares and stallion are to be kept as working-horses, breeding being regarded merely as a secondary object.

A mare may receive the stallion when she has completed her third year, so that she may foal at the age of four years. But for a working-mare, it is better to defer it till the fifth and sixth year, so as not to try her strength too early, and in two ways at once. Mares may very well produce a foal every year; but once in two years is often enough for those which work. They are covered early in the season—in February, if possible—so that they may foal at a time of year when their work can be dispensed with, and they can be properly treated. They must then be fed in the stable, and on very substantial food. The practice of making mares foal in May, so that they may have the advantage of green grass, cannot be adopted with plow-horses.

The time when the mare is in her greatest heat must be carefully observed and taken advantage of, as with cows: this can be done only when there is a stallion on the spot. This usually shows itself from the eleventh day after parturition, and the mare is then particularly disposed to take the stallion. It is from this cause that mares, though they go with young nearly a year, are capable of producing a colt every year at the same time.

It is a very bad plan to have a mare covered twice in the day, or generally even during the same heat, provided she has been already well covered.

The principal sign which indicates that a mare has conceived is, that she rejects the stallion, even while still showing some sign of heat. A mare in foal usually exhibits a certain degree of laziness: she stales frequently, or at least shows a desire to do so. After the lapse of a fortnight, the udder and veins leading to the teats usually swell: this symptom lasts for a week, and then disappears. At the end of the sixth month, the hinder part of the body enlarges, so that the cir-

* The best work hitherto published on this subject is undoubtedly that of "Naumann über die vorzüglichsten Theile der Pferdwissenschaft." 3 Theile. Berlin, 1800–1802. A. This want has been supplied by Mr. Youatt's book on "The Horse."

cumference of the part near the hind-legs becomes as large as that immediately behind the fore-legs: this, however, is not always the case.

In the eighth month the pulsation of the foal may be sometimes felt on applying the hand against the flank of the mother while watering her.

A mare in foal may be used for all ordinary kinds of work—care being taken not to let her get overheated, and never to give her bad food. After the tenth month, however, she must be more cautiously worked—particular care being taken that she be never struck, jerked or made to take violent efforts; her food must also be nourishing, and not inclined to swell. Finally, toward the end of the month, she should have ground corn in her water, to favor the secretion of milk.

When milk appears in the udder, and hollows are formed on both sides of the tail, we may know that delivery is at hand: its approach is also manifested by the restlessness of the mare. She is then usually taken to another stable, where she is provided with soft litter, and coaxed to lie down: this, however, must never be effected by force. Without actual acquaintance with the art of delivery, no one should attempt to assist her, still less to use violent means, such as pinching her nose during the efforts of parturition. If the head of the foal has made its appearance, the extrication of the other parts may, if necessary, be facilitated by stroking gently from above downward.

If the umbilical cord do not separate spontaneously, a ligature is passed round it, at two inches from the foal's body, and it is cut at an equal distance beyond the ligature. No attention is paid to the after-birth, even if it should be a long time coming away.

The foal is usually sprinkled with salt, to induce the mother to lick it.

A warm wash, made of bran, is then immediately given to the mare; she is supplied with it in small quantities at a time, and often.

The mare while suckling must be fed with fodder of excellent quality, and a mash composed of ground rye, and well mixed. After a fortnight she may be put to work again, provided it be done with moderation, and only for half the day. She must not be allowed to overheat herself; but if this should happen, in spite of the precautions taken against it, she must be milked before the foal is allowed to go to her. When the foal is hungry, after a long absence from the mother, it must not be permitted to suck for a long time at once, but removed now and then from the teat.

A small quantity of very good hay is then given to the foal, and he is also allowed to drink of the mash provided for the mother. After eight or ten weeks the foal may be permitted to accompany its mother to the plow, and when she is employed in carting to small distances. Foals are weaned at the end of twelve weeks: some persons profess to have remarked, that those which are allowed to suck for a longer time, though they really grow larger and fatter, are nevertheless weaker when they grow up.

After the foal is weaned, the mare is no longer supplied with the substantial food that she had while suckling. If the udder appears to harden, or is painful to the mare, a hot stone should be placed in a vessel, and the milk made to run upon it, so that the vapor may come in contact with the udder. In this case, also, the udder should be washed and bathed in warm soap and water, and if it becomes very hard, it should be rubbed with burnt butter, or volatile camphorated ointment, procured from the druggist.

Foals are usually reared in a close pasture where there is abundant food for them, and this is certainly the best and most convenient method. Where, however, this convenience is not available, they may be reared in the stable.

When foals are to be brought up in the stable, they are tied up with a halter having a broad nose-band. They should, however, be let out twice a day, if it be only into the yard: but this must be done early, before they become too lively, or they will hurt themselves with all sorts of things. They should be tamed as soon as possible, by being accustomed to eat out of the hand. It is very useful to brush and curry foals from their first year. They should be early accustomed to allow their feet to be lifted up and struck; after the second year, the feet should be trimmed. At the same time a small quantity of oats should be given to them, and the supply of hay diminished; but they thrive very well when fed on green clover and tares.

The horse has twelve cutting teeth or nippers, six in each jaw, four canine teeth or tushes, and twenty-four molar teeth or grinders.

The nippers are subject to change, and afford the chief indication of the horse's age. The young animal is called a foal so long as he retains all his first teeth, that is to say, till the age of two years and a half.

In the third year the two front teeth fall out; those of the lower jaw are usually shed first; the space which they leave is filled up with an equal number of new teeth. These teeth are at first distinguished by a dirty yellow color; in their upper part they have a black cavity called *the mark;* the animal is then called a colt.

In the fourth year the next two teeth in both jaws are changed in a similar manner. The first teeth of the second growth are by this time partially filled up; they are also whiter, and the mark has assumed a pale brown color.

In the fifth year, the two outer teeth change in the same manner, and from that time the animal is a full grown horse.

The three pair of nippers lose their marks in the same order as they gained them. In the seventh year the mark in the center teeth is effaced, in the eighth that in the next two, and in the ninth those of the outer teeth also disappear.

Such is the usual order; there are, however exceptions, especially in certain races. Some horses, particularly the best, shed their teeth later; they also retain the mark longer. Such horses are always more robust, and obtain a more advanced age: hence a horse which retains his marks long fetches a high price.

But horse-dealers try to imitate these marks in their old horses, by piercing or burning the upper part of the teeth, and sometimes do it so cleverly, that only the practiced eye of a connoisseur can detect the imposition. But they can rarely imitate the order in which the marks fill up and

lose their color. The step of the foot in the foal and colt is broader than it is long; but there is often trickery in this—clever enough to deceive any one on casual inspection.

After the tenth year, the first vertebra of the tail separates from the last of the spine, and the separation increases with the horse's age. The gums also contract as the animal grows older, so that the teeth appear longer: these organs also assume a whiteness more like that of lime than before. The cavities above the eyes deepen, the hairs surrounding them grow white, the hind quarters sink, and the lips no longer close. When these signs appear the horse is old, and his value, as far as regards the time that he may be expected to last, depends much more upon them than upon his actual age; for there are many horses which become unfit for use at the age of fourteen, while others continue useful till they are twenty or even twenty-one years old. I knew a horse which carried the post at the age of four-and-twenty.

Grain is generally the principal food of horses; most persons give the preference to oats. But when any other kind of grain is substituted for oats in quantity proportioned to its nutritive power, and mixed with straw of finer quality and greater quantity than usual, the most attentive observers are unable to discover the slightest difference. Rye is the grain most generally substituted for oats. The use of unground barley is disapproved by some persons, because, they say, a large portion of it passes through the body undigested; others, on the contrary, strongly recommend its use. Wheat is rarely used as food for horses: some persons who have been obliged to resort to it have found it very injurious; but various reasons induce me to believe that this evil entirely arose from not mixing the wheat with a proper quantity of cut straw; without this addition it is very apt to clog the stomach. At one time, when this kind of grain was very cheap as compared with others, I gave it to my horses with very good effect, but always mixed with a considerable quantity of cut straw.

The food of a horse is usually measured in oats, this being the most usual food. There is, however, no kind of food which varies so much in nutritive power as oats given by measure. Many persons have, therefore, very judiciously resorted to the expedient of giving their oats by weight, or at least of modifying the quantity according to this method. Of some kinds of oats the scheffel weighs but 36 lbs. while of others it amounts to 54 lbs. In such a case the light oats will not fully supply the place of the heavier, even if the quantity be regulated by weight: nine metzen of the former are not equivalent to six metzen of the latter, because a given weight of the former contains more husk and less farina. Ten metzen of the 36 lbs. variety would probably be required to supply the place of six metzen of the 54 lbs. Taking the 48 lbs. oats, which may be considered very good, as the basis of the calculation, we may reckon three metzen or 9 lbs. for a horse of average size employed in ordinary work; it is understood, however, that the same horse is to have 8 lbs. of hay. With such food horses of this description usually keep up their strength very well; but when they are put to extraordinary work, it is proper to give them an additional quantity of food. Smaller horses, which are not put to forced labor, seldom have more than two metzen even of light oats. The large horses of Saxony, Westphalia, Bavaria, and Austria, are supplied with at least four metzen, and sometimes five. Wagon-horses frequently have eight metzen, especially when but little hay and no cut straw is given to them. The difference of three and five metzen, the former for small, the latter for large horses, is often made without producing any great difference in the size and strength of the animals, or the manner in which they perform their ordinary work. Horses of the smaller races are, therefore, preferable, where they are not continually wanted to draw heavy loads—especially since, even in the latter case, the work may be performed by increasing the number of the horses employed.

Rye, which is most frequently used as a substitute for oats, produces the same effect when given in half the quantity of the latter by measure, or still better by weight. Some persons reckon the proportion of rye to oats for feeding horses only as 7 to 12; they admit, however, that their horses thrive better on the former than on the latter.

The seed of pulse, such as peas, beans and tares, the last of which is considered the best for horses, is not reckoned of greater value than rye. They are, however, decidedly more substantial, as appears from the observations already made on their nutritive properties; and likewise from the testimony of those who are acquainted with this mode of feeding. In many countries these pulse constitute almost the sole nourishment of horses; they do not, as some persons assert, disorder the respiration of the animal. The English give them without reserve to their race horses. The prejudice in favor of oats in preference to all other kinds of grain chiefly arises from this cause, that all diseases which may attack horses fed upon oats, in a country where this mode of feeding is not customary, are imputed to the oats, and the matter is talked of for years; whereas, if the same diseases had attacked horses habitually fed upon this kind of grain, some other cause would have been sought for and discovered. It is certain, however, that very substantial food should be cautiously given, or it will be likely to bring on indigestion. For example, mischief may easily arise when the servants, in the midst of the heavy harvest work, secretly put aside a certain number of sheaves of new rye, and give them to the horses without measuring the quantity; and yet many farmers who are perfectly aware of this trick shut their eyes to it, and regard it as a kind of established custom. Grain of the more substantial kinds likewise requires to be mixed with more or less of finely cut straw; with oats this is not absolutely necessary, though always useful. To prevent the horses from blowing away the chaff, and separating the grain from it, the mixture should be wetted. This wet fodder, though it can never do any injury when cautiously given, will be likely to act as a cause of disorder if the horses are heated and eat it with avidity; an occurrence which will not unfrequently happen, especially when they have been taken to the field before they have finished their meal, and find the rest of it in the manager on their return. There are many reasons for never leaving moist food in the mangers.

Grain given to horses should have undergone fermentation; it should be dry but not heated. In some seasons, badly gathered and heated oats occasion fatal epidemics among horses. Sprouted grain does not injure them, provided it has been housed in a perfectly dry state, and has not contracted a smell of fermentation. Malted grain, particularly barley, mixed with the food is con-

sidered very beneficial to horses, especially when given in the proportion of a third of the total quantity.

Some persons have effected great saving by having their corn crushed before giving it to the horses, for without this preparation a great part of it passes unchanged through their bodies. This may easily be done if we have a mill at our disposal; but there will then be still greater necessity for mixing the corn with cut straw.

The grain must always be sifted to remove the dust, unless it has been subjected to the more effectual process of fanning a short time before.

Most horses are fed upon hay in addition to their corn, and some have nothing else.

Where a choice can be had between the hay of poor, dry, arid meadows, and that of rich, fertile lands, a question arises as to which of the two is the more proper for horses. This is a point upon which opinions are divided. It appears, however, that when hay is mixed with a large quantity of corn, as an accessory kind of food, the hard, poor sort should be given; but where it is to constitute the principal part of the horse's food, the richer and more substantial kind is decidedly to be preferred.

It is certain that hay may be substituted for corn-feeding, but opinions are divided respecting the extent to which this substitution ought to be carried; and likewise with regard to its economical expediency; in fact, it is impossible to lay down any general rule on the subject. Eight pounds of hay are generally regarded as equivalent to a metzen of oats; and when estimated by weight, hay is said to bear to oats the ratio of eight to three. Very nutritious hay, grown on low meadows, or fodder made from clover, lucerne, or sainfoin, is undoubtedly more substantial, and may be estimated in the proportion of seven to three; whereas the same kinds of fodder, when coarse and poor, do not exceed the ratio of nine to three. But, generally speaking, it is found that when the quantity of hay is increased and that of corn diminished, the horses gain more flesh and are better able to perform slow work, but do not stand long journeys or great exertion so well. If, on the contrary, the hay is diminished, and the corn increased in quantity, the horses grow lean, but become stronger and more lively; provided, however, that their supply of straw is increased. An increase in the quantity of one or the other kind of food will be found advantageous according to the particular circumstances in which we may be placed, and the prices of various kinds of fodder.

Some farmers think that the aftermath or second hay-crop is decidedly injurious to horses; but this is not the case when the hay is harvested dry and green, and grown on upland meadows, even though they are somewhat arid. The aftermath of rich meadows may perhaps be less fit for horses than for horned-cattle. Many experienced farmers, however, do not like to have the aftermath consumed till February or March. The longer the hay is left in cocks, the better is it adapted for horses: the best hay for them is that which is more than a year old. Hay for horses must be well made, and dried as quickly as possible, in order to preserve its green color and peculiar smell; brown hay is not proper for these animals.

Beside the cut straw, other straw is likewise given to horses, particularly that which has been most broken in threshing; this is put into the rack. Contrary to general opinion, wheat straw is the best; it is the most proper substitute for hay when that kind of fodder is deficient, and is likewise the kind of straw which horses eat most willingly. The haulm of tares, lentils and beans are, doubtless, still more nutritous, especially when part of their leaves are left on them in the green state. Some farmers are afraid to give pea-straw; they say that it sometimes brings on colic; but this opinion is founded on mere prejudice.

Opinions are divided respecting the propriety of feeding horses in the stable on clover and other kinds of green-meat. For my own part I am persuaded that horses may be kept in this manner in good health and full vigor; at least when a proper system is pursued. It is, however, the quantity of this fodder, and the price current of grain, which determine the amount of saving that may be obtained by this mode of feeding. I kept my horses in this way for several years, when corn was high-priced, and always with advantage: they improved in condition without losing strength even when they are not spared in respect of work. In the following winter, also, they were in surprisingly good condition. The transition from dry to green fodder must, however, be gra lually made. At first, the clover must be cut up with straw; and first one portion of it, then two given daily in place of oats; afterward, when the clover is in flower it is given to them in as great a quantity as they like; but then the corn is stopped. It is not good to give corn with green-meat, because the former then passes through the body undigested. If corn and green feeding are to be united, the corn must then be given in the morning, and the horses not allowed any green fodder before noon, or any corn in the after part of the day. Green lucerne and tares (especially the latter) which have begun to form their pods, are better for horses than clover. The same gradual change must be observed in passing from green to dry feeding.

Horses are sometimes turned out to grass in summer, either with the other cattle, or in fields by themselves. If they are properly attended to, and left completely at rest, this removal to their natural state agrees with them perfectly well. But horses cannot often be left unemployed, and therefore it is rarely possible to have them turned out to grass. For a horse to thrive when fed in this manner, the pasturage must be abundant, but he will then spoil a great deal of it with his feet; hence two cow-pastures are reckoned for one horse-pasture.

We cannot here treat of the pasturage of horses on marshes or commons. These can rarely be used for working horses, especially when they are at a considerable distance. They are more useful for brood-mares and colts.

It is certain that plow-horses may be fed from autumn till the time when young green fodder can be procured, without the aid of corn, by means of roots and a large quantity of hay and straw; upon such food horses may be maintained in full vigor and perfect health. They will not, however, be fit for long journeys, such as are required in winter for the transport of produce.

The most suitable and profitable food for horses consists of carrots, washed and coarsely mash-

ed, or cut. Twelve metzen of these vegetables are given with eight pounds of hay and a due proportion of straw, when the horses are to be put to laborious work. This plan of feeding is universally adopted in some counties of England, and found highly successful. In this country, also, it is well known that, when horses know the taste of carrots, they eat them with avidity, and thrive upon them.

As to potatoes, many farmers who have tried them have been very well satisfied with the result; others have not been able to accustom their horses to these vegetables, or have found that the animals lost strength when thus fed. I am not able to decide whether in the latter case the food was properly given. I have never tried this mode of feeding with my own horses, because it has never been consistent with my system of management. The potatoes should first be carefully washed, and then coarsely broken up. The horses may be accustomed to these vegetables by playing with them, making them eat out of the hand, then putting a few pieces on their food, and gradually increasing the quantity. If it be desired to substitute potatoes entirely for corn in feeding horses, each animal must have half a scheffel (50 lbs.) per day. But perhaps it is better to take away only half the corn and give four metzen of potatoes, in place of one and a half metzen of oats. The horse must likewise be supplied with hay and straw as usual. Some persons steam the potatoes. In a large factory in England eighty horses are kept on food thus prepared; when the same method has been tried in this country, the horses have absolutely refused to eat the potatoes.*

Turnips of the kind admitting of transplantation, and ruta-bagas, have also been tried as food for horses, and eaten by them as greedily as carrots. The animals must, however, be gradually accustomed to them in the same manner as to bread.

Some farmers feed their horses on nothing but the refuse of the threshing-floor mixed with hay and cut straw: when, however, the horses are required to work, they are allowed a feed of corn. In establishments where horses are but little used in winter, this plan of feeding may be sufficient. Brood-mares are often kept in this manner in studs, where they are not required to work.

All food should be given to horses in small portions. A horse should commonly be allowed three hours to eat; the attendants must, therefore, get up three hours before work begins, to give them their first feed. The hours of feeding should be regularly observed.

Horses should be watered with great care in the stable and when quite cool. Water may indeed be given to them on the road, but they must be made to go on immediately afterward. It is improper to give them drink immediately after they have eaten corn; they should have some hay first. Some persons think that hard water is best for horses; but they prefer soft water, and drink more willingly from ponds than from clear springs. Hard spring-water should therefore be exposed to the air for some time before it is given to horses.

Cleanliness is of great importance to the health of the horses; if it be neglected, a crust of sweat and dust collects on the skin, and gives rise to mange and other diseases. Agricultural horses cannot, indeed, be treated with all the minute attention bestowed on pleasure horses; such as currying, brushing, dusting, and washing every time they return to the stable; but, at all events, they should be curried every morning, and have their hams, knees and feet washed every evening, when they have got dirty. A smooth shining coat, which lazy grooms can produce by washing the horses entrusted to their care, often conceals a great deal of dirt attached to the skin: but this is easily discovered by passing the finger forcibly the wrong way of the hair. As plow-horses cannot well be perfectly cleaned every morning, the operation should be performed at least once a week, on Sunday morning. Bathing is doubtless very beneficial to horses: not in the evening, when they return from work heated and tired, but in the morning.

The shoeing of the fore-feet is indispensable, excepting for horses which either work on sandy soils, or have peculiarly solid hoofs, a very valuable property, hereditary in certain breeds. The shoeing of the hind feet is often dispensed with where the roads are not very stony. In rural districts, where there is not much choice of farriers, shoeing is often very badly performed. The farmer should, therefore, take an opportunity of acquiring a good practical knowledge of the art of shoeing, that he may be able to direct and control the farrier. The shoe should fit the hoof exactly, after the latter has been properly pared. Particular care must be taken to guard against pricks, which result from a horse running a nail into his foot as he walks, or from a nail taking the wrong direction in shoeing: when this happens, the nail must be immediately extracted.

Colts must be accustomed at an early age to allow their feet to be lifted up and struck: they are not however, shod till wanted for tolerably regular work. Broken or damaged shoes must never be left on the feet: they must be taken off as soon as the hoofs project beyond them; but may be replaced, if strong enough to be used again. For this purpose, horses should be sent to the forge about once a month.

Agricultural horses which are almost always out of doors do not require stables so spacious, lofty and light as others which are at rest for the greater part of their time; nevertheless, the stable should be so constructed as to be moderately warm in winter, and cool in summer. Ventilation should be effected by means of windows; but above all things, arrangements must be made for completely carrying off the urine. The stalls should be so formed as to allow the horses to lie down, which, from the little sleep that they have, is very beneficial to them. Some horses never lie down; it is chiefly by constantly remaining in narrow stalls, that they acquire the habit of always standing upright. For instructions as to the mode of building stables for horses, I refer to the work of Gilly, already cited.

Young horses must be gradually accustomed to labor: the surest mode of effecting this ob-

* Probably because they were too watery and too much mashed: perhaps also because they had been allowed to turn sour. When boiled potatoes are to be given to horses, they must be prepared with great care, and day by day; they should also be boiled in steam, and not in water. I think, however, that boiled potatoes make the stomachs of animals sluggish; I therefore give them only to those which are to be fattened. Horses fed on them grow sensibly fatter, but do not become spirited: they seem, indeed, rather to grow lazy. [*French Trans.*

ject is to attach them to a plow on a light soil. At first they should be entrusted only to very intelligent men, and constantly watched. Under these conditions, a colt may be used from the age of 2½ years, but only with moderation, and never for a whole day together: for this he will not be able to bear till he is four years old. He must be gradually accustomed to work for a longer time, and drag heavier loads. By this treatment he will gain strength, and not be injured, provided he be made to walk gently and regularly. A horse is rarely injured, even at hard work, when made to go slowly; it is by being forced to travel with excessive speed that he becomes heated and worn out.

Great regularity should be observed in the hours of labor. A plow-horse may, without exhaustion, be worked for six hours every day at ordinary work; if the time be divided into two equal portions, by a meal in the middle of the day: but they must not be taxed to the utmost, except in cases of necessity. In the winter season, when these periods are too short, the horses may be allowed to work for six or seven hours together: this may even be necessary when they are employed to draw loads to considerable distances.

As the feed of horses is increased when they are very hard worked, so also it may be diminished when they are unemployed, by taking away part of the ordinary allowance of corn: the diminution, however, should never exceed a third of the whole allowance.

A horse being an expensive animal, and very liable to injury, he should never be entrusted to any driver but one who is very steady and trustworthy. If it be necessary to employ drivers in whom we cannot place entire confidence, they should never be trusted out of sight: above all, they must not be sent upon journeys, excepting under careful superintendence.

The director of a rural establishment should frequently examine the harness of his horses, to see that it fits well, that all injuries are promptly repaired, and that it is greased and cleaned as often as required: servants seldom take any interest in these matters. I should recommend particularly in establishments which often change their servants, that no mode of harnessing be adopted different from that which is commonly practiced in the country, even though a more advantageous method should be known.

There is some advantage in yoking four horses two by two, rather than in single file: but the former method requires the employment of men who perfectly understand driving and riding, and will take a liking to the horse which they mount, and spare him as much labor as possible; otherwise, the horse so used will certainly be exhausted and quickly worn out. There is some difficulty in changing the carrier in a team.

FINIS.

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